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Osprey and Bald Eagle Productivity And Habitat Use in the Williston Reservoir Watershed, North-Central BC, 1997

M. Merkens, B. Booth and M. D. Wood
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Peace/Williston Fish and Wildlife Compensation Program, 1011 Fourth Ave. 3rd Floor, Prince George B.C. V2L 3H9

Website: *www.bchydro.bc.ca/environment/initiatives/pwcp/*

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Author(s): Markus Merkens[1], Barry Booth[2] and Mari D. Wood[3]

Address(es): [1] Pure and Applied Wildlife Research, 8463 12th Avenue, Burnaby, BC V3N 2L8
[2] Pure and Applied Wildlife Research, 2822 West King Edward, Vancouver, B.C. V6L 1T9
[3] Peace/Williston Fish and Wildlife Compensation Program, 1011 Fourth Ave., 3rd Floor Prince George, B.C. V2L 3H9

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Abstract

Occupancy and productivity surveys for ospreys *(Pandion haliaetus)* and bald eagles *(Haliaeetus leucocephalus)* were conducted by helicopter from April to August 1997 around the Williston Reservoir (Central British Columbia) and a series of lakes and rivers in the vicinity of the reservoir. Clutch initiation dates, clutch size, productivity and nest site characteristics were recorded for both species during 8 flights. In total, 1,770 km of reservoir shoreline, 1,042 km of river, and 270 km of lake shoreline were surveyed. During these surveys 151 osprey nests and 142 bald eagle nests were located of which 50% (76) and 46% (66), respectively, were occupied. Overall mean clutch sizes for ospreys and bald eagles were 2.73 ± 0.08 eggs/occupied nest and 1.90 ± 0.04 eggs/occupied nest, respectively. Mean productivity for ospreys was 1.14 ± 0.14 young/occupied nest and 2.23 ± 0.13 young/successful nest. Productivity for osprey nests located along rivers was not significantly different than for reservoir osprey nests. Osprey productivity varied between different reaches of the reservoir. Mean productivity for bald eagles was 0.71±0.10 young/occupied nest and 1.42±0.09 young/successful nest. Bald eagle productivity did not significantly differ between reservoir, river or lake nest sites nor did it vary significantly between reaches of the reservoir. Osprey and bald eagle productivity within the reservoir during 1997 was not significantly different than in 1995.

Ospreys tended to use snags in relatively advanced stages of decay that were located within or very near to the inundation zone of the reservoir. Bald eagles, on the other hand, tended to nest in live deciduous tree species and were rarely found within the inundation zone. Bald eagles did nest in close proximity to the reservoir margin. Nest tree and site characteristics varied between reaches of the reservoir for both species.

It was determined that, of nest trees found during previous (1995) surveys, 28% and 23% of osprey and bald eagle nests, respectively, had been lost over a two year period. Furthermore, 5 osprey nests that were occupied early in 1997 failed due to flooding or nest tree failure.

Recommendations for future research and mitigation in terms of habitat enhancement include: new surveys to be conducted in 5 years; followed by nest site use and availability studies for both species , more intensive surveys examining bald eagle biology in the reservoir, and construction of new artificial nesting platforms for osprey use should they be deemed necessary after surveys conducted in 2002.

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1.0 INTRODUCTION

Bald eagle (*Haliaeetus leucocephalus)* and osprey (*Pandion haliaetus)* breeding distributions include lakes, rivers, and coastal areas throughout much of British Columbia (Campbell et al. 1990). Breeding populations of bald eagles tend to be primarily clustered along the coast, while nesting osprey populations tend to be concentrated around interior lakes and rivers. Fish make up a significant portion of both species' diets during breeding season, and both are open nesters that require large trees to support their stick nests.

In 1968, the W.A.C. Bennett Dam was constructed on the Peace River in northeastern B.C., creating the largest body of freshwater in the province. The resulting 1,778 km^2 Williston Reservoir flooded a portion of the Peace River, and the lower Finlay and Parsnip Rivers. In 1988, the Peace/Williston Fish and Wildlife Compensation Program (PWFWCP) was initiated to enhance and protect fish and wildlife resources affected by the construction of the W.A.C. Bennett Dam and creation of the Williston Reservoir. The program is a cooperative venture between B.C. Hydro and the Ministry of Environment, Lands and Parks, and is supported by funding from B.C. Hydro.

No data existeded on the distribution and abundance of breeding bald eagles and ospreys prior to or after reservoir impoundment until 1995, when the PWFWCP initiated a project to investigate the osprey and bald eagle populations in the Williston Reservoir watershed (Zemlak et al. 1995, Booth et al. 1999). The objectives of this project were to first determine the population status, nest habitat use, and nesting distributions of bald eagles and ospreys along the perimeters of the Williston and adjacent Dinosaur Reservoirs, and secondly, to undertake measures to protect and/or enhance habitat and population numbers if and where necessary.

During two aerial surveys conducted in 1995, 98 osprey and 61 bald eagle nests were located around the Williston Reservoir of which 87 and 36 were occupied, respectively (Booth et al. 1999). Data collected during the occupancy and productivity surveys revealed that the mean productivities for occupied osprey and bald eagle nests were 1.18 and 0.86 fledglings, respectively. These data also indicated that a significant number of nests had failed. The two surveys completed during 1995 were not sufficient to accurately assess productivity for both species. It was apparent that bald eagles tended to breed earlier than ospreys in the Williston watershed and therefore, these two species should be surveyed for productivity separately so that accurate productivity estimates could be obtained for the Williston breeding populations.

Although the 1995 surveys provided baseline data on breeding densities, more accurate productivity estimates on which to base enhancement and protection efforts were needed. The primary objective of the 1997 surveys was to obtain more accurate productivity estimates for both species by 1) monitoring clutch initiation within the Williston watershed and timing the productivity flights to coincide with the time when there was maximum likelihood of identifying actual fledgling numbers, and 2) conducting separate occupancy and productivity flights for each species. The secondary objective was to compare densities and productivities of populations of both species nesting along the reservoir with those nesting along natural waterbodies, by expanding the survey area to include lakes and rivers in Williston Reservoir watershed.

This report presents and analyzes the productivity and nest habitat data collected in 1997, and makes recommendations for future project direction. In addition, existing information on fish species distributions and abundance within the Williston Reservoir and its tributaries are examined.

2.0 STUDY AREA

The study area encompasses the Williston Reservoir watershed in north-central British Columbia, and includes the Williston Reservoir and it's major tributaries, the Dinosaur Reservoir, and four natural lakes (Figure 1). In 1968, the W.A.C. Bennett Dam on the Peace River was completed, impounding the upper Peace River and the lower sections of the Finlay and Parsnip Rivers to form the Williston Reservoir, B.C.'s largest body of fresh water. The Williston Reservoir has a surface area of 1,778 km^2, and a shoreline perimeter of 1,770 km (BC Hydro 1988). Several major river systems flow into the reservoir, draining an area of 69,930 km^2 (BC Hydro 1991). The completion of the Peace Canyon Dam in 1980, 23 km downstream of the W.A.C. Bennett Dam, created the smaller Dinosaur Reservoir with a surface area of 8 km^2 and a shoreline perimeter of 54 km (BC Hydro 1987).

The majority of the study area lies within the Sub-Boreal Interior Ecoprovince with two exceptions: the watersheds flowing into the north end of the Williston Reservoir which lie in the Northern Boreal Mountains Ecoprovince, and the eastern end of the Dinosaur Reservoir which lies in the Boreal Plains Ecoprovince (Demarchi 1995). Much of the forested land surrounding the Williston Reservoir is within the Sub-Boreal Spruce (SBS) biogeoclimatic zone with the majority in the moist cool variant (SBSmk2). The moist cool (mk1) variant occurs at the southern end of the Parsnip Reach, while the wet cool (wk2) variant occurs along the west half of the Peace Reach. The Boreal White and Black Spruce (BWBS) biogeoclimatic zone occurs at the northern tip of the Finlay

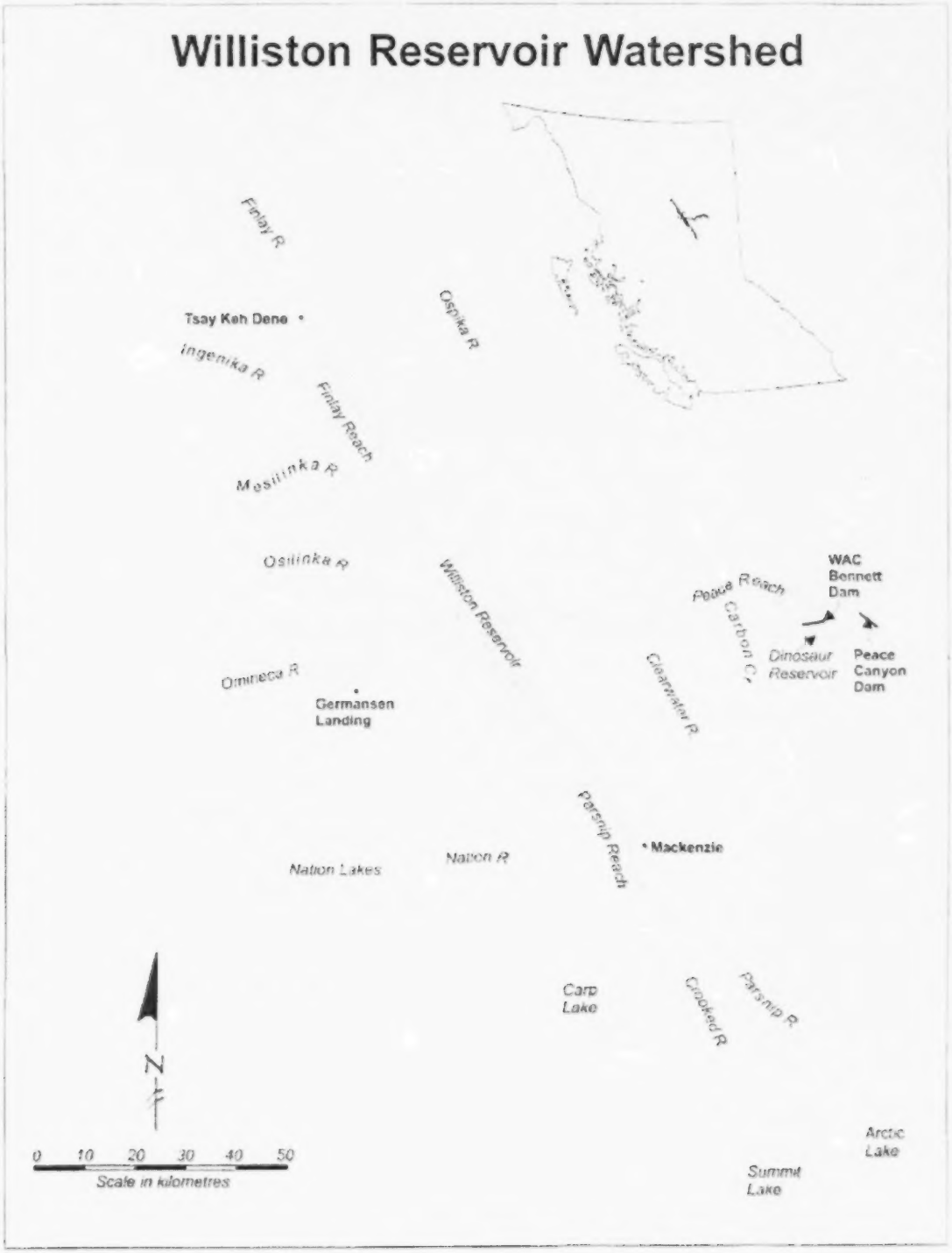


Figure 1. Williston and Dinosaur Reservoirs and associated tributaries in north-central B.C.

Reach (dry cool variant dkl), and along the eastern half of the Peace Reach including the Dinosaur Reservoir (moist warm variant mwl) (MacKinnon et al. 1990, DeLong et al. 1993).

In addition to the two reservoir perimeters, 11 major tributaries to the Williston Reservoir and four natural lakes in the watershed were also surveyed (Figure 1, Table 1). Four of the six rivers flowing into the Finlay Reach occur in the BWBSdkl variant (Finlay, Ingenika, Osilinka, Omineca) while two occur in the SBSmk2 variant (Mesilinka, Ospika). The Carbon and Clearwater Rivers on the south side of the Peace Reach lie within the SBSwk2 variant. Three rivers flow into the Parsnip Reach and each bisects multiple variants of the SBS zone. The Parsnip River lies primarily in the wkl variant, the Crooked River occurs in both the mkl and wkl variants, and the Nation River lies

Table 1. Summary of BEC zones, elevations and lengths of reservoir shoreline, rivers, and lakes surveyed in 1995 and 1997.

Waterbody System	Geographic Area	Biogeoclimatic Designation	Length surveyed (km)	Elevation at survey end point (m)
Williston Reservoir:				
Parsnip Reach	n/a	SBSmkl/mk2	580	670
Finlay Reach	n/a	BWBSdkl/SBSmk2	695	670
Peace Reach	n/a	BWBSmwl/SBSwk2	495	670
Dinosaur Reservoir	n/a	BWBSmwl	54	600
Finlay River	Finlay Reach	BWBSdkl	170	900
Ingenika River	Finlay Reach	BWBSdkl	95	875
Osilinka River	Finlay Reach	BWBSdkl	57	875
Omineca River	Finlay Reach	BWBSdkl	162	850
Mesilinka River	Finlay Reach	SBSmk2	60	850
Ospika River	Finlay Reach	SBSmk2	65	875
Carbon River	Peace Reach	SBSwk2	13	800
Clearwater River	Peace Reach	SBSwk2	16	775
Parsnip River	Parsnip Reach	SBSwkl(mkl/wk2/vk)	166	750
Crooked River	Parsnip Reach	SBSmkl/wkl	132	700
Nation River	Parsnip Reach	SBSmk 1(mk2/wk2)	106	850
Nation Lakes	Nation River	SBSmkl	150	875
Carp Lake	Crooked River	SBSmkl	80	850
Summit Lake	Crooked River	SBSmkl	40	700

primarily in the mk1 variant. The Nation Lakes (Chuchi and Tchentlo), Carp Lake, and Summit Lake, are the four largest natural lakes below 900 m elevation in the watershed. All lie within the SBSmk1 variant in the southern part of the study area.

The major tree species found along the perimeters of the Williston and Dinosaur Reservoirs are white spruce *(Picea glauca)*, lodgepole pine *(Pinus contorta)*, and trembling aspen *(Populus tremuloides)*, with smaller pockets of black cottonwood *(Populus trichocarpa)* and paper birch *(Betula paperifera)*. Since much of the landbase under the Williston Reservoir was not logged prior to flooding, standing snags are found along many sections of this reservoir's shoreline, and are common in many of its shallow bays. The topography adjacent to the Finlay and Parsnip Reaches of the Williston Reservoir is gently to moderately sloping, with some steep cutbanks. The Peace Reach contains the deepest part of Williston Reservoir and many sections of the shoreline are dominated by steep rock cliffs. The shoreline of Dinosaur Reservoir has moderate to steep forested slopes. Standing snags are virtually absent along the shorelines of the Peace Reach and Dinosaur Reservoir.

White spruce and lodgepole pine also dominate the natural lake shorelines and river banks, with generally fewer deciduous trees. Rivers with extensive floodplains in their lower sections including the Parsnip, Omineca, Ingenika, Finlay, and Ospika, contain a greater abundance of cottonwood and aspen. Douglas-fir *(Pseudotsuga menziesii)* reaches it's northern-most limit in B.C. just north of Prince George, and the southern half of the Crooked River and Summit Lake are the only areas where Douglas-fir exists within the survey area. Many large veterans are present in the area.

The level of Williston Reservoir fluctuates annually due to the amount of inflow, and the demand for hydroelectric power generation. In winter, the demand for electricity is high while inflow from the tributaries is low, and the reservoir typically reaches its lowest level in April. The reservoir rises throughout the summer due to increased snowmelt and decreased demand for power, reaching it's highest level in September. The reservoir level fluctuates between the normal minimum elevation of 655 m, and full pool at 672 m. The Finlay and Parsnip Reaches of Williston Reservoir usually freeze over by December, while the deeper Peace Reach freezes by early January. Ice breakup starts in the rivers and streams in mid-April, and typically occurs in the reservoir in the first week of May. The first few kilometers of the Dinosaur Reservoir downstream of the W.A.C. Bennett Dam remain ice-free throughout the year, while the remainder freezes over by January and is normally ice-free by April.

Human development in the Williston and Dinosaur Reservoir watersheds is minimal, and includes the small towns of Mackenzie (south end of the Parsnip Reach) and Hudson's Hope (near

the Peace Canyon Dam), the small communities of Germansen Landing (Omineca River) and Manson Creek, and the First Nation communities of Tsay Keh Dene (north end of Finlay Reach), Fort Ware (Finlay River), and McLeod Lake (Crooked River). A number of logging camps are distributed throughout the watershed. Forest harvesting is the primary industrial activity in the watershed, with the reservoir used as a transportation corridor for timber. Both reservoirs and the Nation Lakes receive low to moderate use by recreationalists, primarily for boating and fishing. Carp and Summit Lakes receive moderate to high use in both summer and winter, owing to their proximity to Prince George, and to their provincial campground and recreational properties, respectively.

There are many fish species that may be potential prey for osprey and bald eagles present in the Williston Reservoir watershed. Spring-spawning species include rainbow trout (*Oncorhynchus mykiss)*, Arctic grayling *(Thymallus arcticus)*, lake chub *(Couesius plumbeus)*, peamouth chub *(Mylocheilus caurinus)*, northern squawfish *(Pyychocheilus oregonensis)*, longnose dace *(Rhinichthys cataractae)*, redside shiner *(Richardsonius balteatus)*, suckers *(Catostomus sp.)*, and sculpins *(Cottus sp.)* (McPhail and Carveth 1993). Fall spawning species include kokanee *(Oncorhynchus nerka)*, bull trout *(Salvelinus confluentus)*, lake whitefish *(Coregonus clupeaformis)*, and whitefish species *(Prosopium sp.)*. Since ospreys and bald eagles cannot dive to great depths to capture prey, other fish species in the reservoir such as burbot *(Lota lota)* and lake trout *(Salvelinus namaycush)*, which typically reside in deep waters, are less likely taken as prey.

3.0 METHODS

3.1 Survey Methods

In March 1997, we surveyed nine major tributaries to the Williston Reservoir and four natural lakes to document the locations of osprey and bald eagle nest sites. The nest search survey was conducted in late winter when nests were filled with snow and deciduous trees lacked their leaves, which increased the visibility of the nests compared to summer conditions. The survey was conducted using a Bell 206 Jet Ranger helicopter equipped with bubble windows flying 50-100 m above the ground at speeds ranging from 130-160 km/hr, with two observers searching 300 m inland for nests. Wide rivers were surveyed by flying along the edge of one shore then returning along the opposite shoreline, with both observers sitting on the same side of the aircraft. Narrow rivers were surveyed by flying up the middle of the river, with the two observers sitting on opposite sides of the helicopter. Most rivers were surveyed to their headwaters, or to a maximum of 900 m elevation. Some river surveys were concluded prior to 900 m if the nesting habitat was noted to become

increasingly unsuitable (i.e. the valley became steeper, the river channel narrowed substantially, or the deciduous species completely dropped out).

At each nest site located we recorded tree species, tree status (dead, live), visually estimated tree decay class (Guy and Manning 1994), nest position (crotch, top), suspected raptor species, distance from water, and general attributes of surrounding forest. Latitude and longitude for each nest site were recorded using the on-board Global Positioning System (GPS) unit in the helicopter (NAD83 datum). Photographs of every nest site were taken. The entire perimeters of the Williston and Dinosaur Reservoirs were surveyed in 1995 to document nest locations (Zemlak et al. 1995; Booth et al. 1999); the reservoir perimeters were not surveyed again in 1997.

A two or three person crew plus pilot conducted occupancy and productivity surveys throughout the spring and summer of 1997 using a Bell 206 Jet Ranger. The person in the front passenger seat of the helicopter was responsible for navigating, searching for nest sites, counting eggs, fledglings, and adults, and recording GPS coordinates of each nest site. The two rear seat observers searched for nest sites and counted eggs, fledglings and adults. One rear seat observer recorded the data collected, while the other photographed the nest sites. Two additional rivers along the Peace Arm (Carbon and Clearwater) were surveyed for nest locations during the eagle occupancy survey. New nest sites incidentally observed during the occupancy and productivity surveys were also documented.

Four surveys were conducted for each raptor species: two clutch initiation flights, an occupancy survey, and a productivity survey (Table 2). The clutch initiation flights involved monitoring clutch initiation at 25-30 nests to aid in determining the best time to conduct the main occupancy and productivity flights for each species. The sample nests for eagles were located in the Parsnip Reach, and the lower Parsnip and Crooked Rivers, while the sample osprey nests were located in the Parsnip Reach. The ideal timing for occupancy surveys is after all birds have laid their clutches, but prior to hatching.

The main occupancy and productivity surveys commenced about two hours after sunrise and ended one hour before dark. All nest sites around the reservoir (documented in 1995) as well as those along rivers and lakes (documented in 1997) were revisited using the helicopter's GPS unit to assist in relocating them. The main objectives of the occupancy surveys were to document nest occupancy, clutch size, and disturbance rates. Data collected at each nest site included the bird species using the nest, the number and behaviour of adults present, and the number of eggs or chicks in the nest. All nests were revisited again during the productivity surveys (including those that

appeared unoccupied on the occupancy survey to verify their status). Data collected included the number of fledglings in each nest, and the number and behaviour of adults in the vicinity.

The level of Williston Reservoir rose substantially throughout the eagle and osprey's breeding season (Table 2). The reservoir rose 13.7 m between the eagle occupancy flight in early May, and the fledgling success flight in early July. The reservoir was 6.7 m higher during the osprey productivity flight in early August compared to the mid-June occupancy flight.

3.2 Data Summary and Analyses

3.2.1 Data Entry and Mapping

Nest site locations were entered into an Excel database after each survey flight. The nest sites located along the reservoirs in 1995, and along the major rivers and natural lakes in March 1997, were mapped using the QuickMap Computer Mapping System, and used to plan survey routes for the occupancy and productivity surveys. Final 1:250,000 mapsheets of the 1997 nest locations and status (species and occupancy) were produced using QuickMap upon completion of the surveys and data entry.

5.2.2 *Nesting Terminology*

Terminology regarding nest status follows that of Postupalsky (1974). An 'occupied' nest is one that was attended by two adults early in the breeding season. An 'active' nest was a nest with visible eggs, nestlings and/or fledglings at some time during the aerial surveys, or a nest with an

Table 2. Summary of aerial nest surveys and relevant Williston Reservoir levels during 1997.

Survey	Date	Length (hrs)	Reservoir Level (m)	Reservoir Level Increase (m)[1]
Bald Eagle clutch initiation survey #1	10 Apr	2.2	655.1	n/a2
Bald Eagle clutch initiation survey #2	25 Apr	2.0	654.4	n/a
Bald Eagle occupancy survey	5-7 May	18.6	654.9	0.5 (0.5)
Osprey clutch initiation survey #1	16 May	1.8	656.4	1.5 (2.0)
Osprey clutch initiation survey #2	3 June	1.8	661.3	4.9 (6.9)
Osprey occupancy survey	10-11 June	12.0	663.7	2.4 (9.3)
Bald Eagle productivity survey	8-9 July	15.1	668.6	4.9(14.2)
Osprey productivity survey	11-12 Aug	9.4	670.4	1.8 (16.0)

[1] Increase in Williston Reservoir level from previous survey date. Values in brackets represent increase in water level from 25 April 1997.

[2] n/a = Reservoir frozen

incubating adult in it. We assumed that adults exhibiting incubating behaviours or posture had eggs present in that nest at that time. A 'successful' nest is one in which at least one young was observed nearing or beyond fledging on the productivity surveys.

Unoccupied nest sites were identified as either bald eagle or osprey nests during surveys, or through examination of photographs of nest sites after surveying. We classified large nests in the crotches of trees where part of the canopy extended above the nest as bald eagle nests, and nests located on the very top of a snag or live tree as osprey nests. Numerous unoccupied nests could not be classified as to species .

5.2.5 *Productivity*

Productivity was calculated as both the # young/successful nest, and the # young/occupied nest, as the number of young/successful nest is considered to be a biased estimator of productivity (Steenhof 1987). The # young/occupied nest is based on the assumption that the nest sites where no fledgling data were available actually represented nest failures, however, the lack of fledgling data for some nests may have resulted from young having already left the nest. We felt justified in including these nest sites as nest failures because they fell within the range of nest failures reported in other bald eagle and osprey studies. This estimate represents the "worst possible" productivity for the nest sites analyzed. Estimates based on the 1997 data likely represent more accurate fledgling counts than from surveys completed in 1995, given the better timing of the occupancy and productivity flights which coincided with estimated optimal occupancy and fledgling periods.

Clutch sizes and productivity for both osprey and bald eagles are presented for the overall study area, by habitat type (reservoir, river, lake), and by reach and subarm within the Williston Reservoir. For ospreys, a Mann-Whitney U-test, and Student's t-test, were used to compare clutch size and productivity respectively, between reservoir and river nests. A t-test was also used to test for differences in productivity of occupied and successful nests between the Finlay and Parsnip Reaches. For eagles, Kruskal-Wallis one-way ANOVA was used to test for differences in both clutch size and productivity between nest sites located in reservoir, river and lake areas. ANOVA was used to test for differences in productivity between the three reaches of the Williston Reservoir.

A number of osprey nests along the Williston Reservoir were located in locally dense aggregations or "colonies". No formal definition of an osprey colony exists in literature and for the purposes of this study we define a colony as any group of 3 or more nests within 200 m of each other. To test if birds nesting within colonies were more productive than non-colonial nesting birds, the productivity of occupied nests was compared between colony and non-colony nest sites using the

Student's t-test. Three colony nests flooded out by rising reservoir levels, were excluded from this analysis because failure of these nests was related to unnatural causes.

Bald eagle nests located along the rivers during 1997 surveys occurred in two different biogeoclimatic zones (SBS and BWBS). To test for differences between the two zones, productivity of occupied nests was compared using a t-test. Productivity of ospreys and bald eagles during the 1997 breeding season was also compared to productivity data gathered in 1995 (Booth et al. 1999) using Student's t-tests.

3.2.4 Nest Tree Characteristics

The number of occupied and unoccupied bald eagle and osprey nests located within the survey search area were summarized by decay class, and distance from shoreline. Bald eagle nests were also summarized by tree species. Some nest sites where data were missing were excluded from comparisons. Decay class and distance from shoreline distributions were analyzed using Chi-squared tests for each species (G-tests - Sokol and Rohlf, 1981). Pairwise comparisons of decay classes and distance from shoreline between occupied and unoccupied nests were completed for each species. Nest tree decay class and distance from reservoir shoreline for occupied nests was further compared among the main reaches of the reservoir for each bird species. Pairwise comparisons between occupied river, lake and reservoir nests were also made for decay class and distance to shoreline for eagle nests. For these analyses some decay classes or distance classes were combined when necessary (i.e. whenever there was an empty data cell in individual comparisons).

4.0 RESULTS

4.1 Ospreys

4.1.1 Timing of Clutch Initiation

Twenty-nine (29) osprey nests were visited on two clutch initiation surveys. On 16 May, 86% (25) of the nests were attended by at least 1 adult, 3 of which had 1 egg. By 3 June, 83% (24) of the nests were attended by adults and 62% (18) had at least 1 egg. Of these 18 nests, 89% (16) contained 3 eggs. This suggests that 75% of the potentially occupied osprey nests in the study area had initiated clutches by early June.

4.1.2 Nest Site Density and Distribution

During the 1997 surveys, 151 osprey nest sites were recorded; 114 of these were used for analyses. Of the 37 nests excluded from the analyses, 12 were incidentally observed outside the 300

m search zone from a waterway edge, while three nests were located within the search zone but were geographically isolated from the majority of the osprey nests rendering data collection cost ineffective. During the 11-12 August productivity survey, 27 previously unrecorded nests were found within the search area, however, 22 of these were classified as nests of unknown occupancy status since there were no adults or fledglings present and were therefore excluded from the analyses. Of the 114 nests, 67% (76) were determined to be occupied in 1997.

The distribution of osprey nests was not uniform along the entire Williston Reservoir shoreline (Figures 2, 3; Table 3). The majority of occupied nests were located within the Parsnip (49%) and Finlay (46%) reaches of the Williston Reservoir, similar to the distribution of unoccupied nests (Parsnip 53%, Finlay 32%). No occupied osprey nests were located within the Peace Reach of the Williston Reservoir, or along the lakes surveyed. Manson Arm, a moderately sized inundated bay within the Parsnip Reach, contained 26% of all occupied nests found within the Williston Reservoir. Five colonies ranging from 4 to 6 nests per colony were located in Manson Arm itself, and a small bay to the north. Distances between occupied nests wihtin these colonies were as short as approximately 50 m (as estimated during the aerial survey).

Although all surveyed areas were intensely searched, it is unlikely that all osprey nests within the search area were found given that we located 27 new nests on the last survey. Therefore, the calculated breeding densities of 0.04 occupied nests/km of reservoir shoreline, and 0.004 occupied nests/km of river, are minimum estimates. Nest densities within the Parsnip and Finlay Reaches of the Williston Reservoir were 0.06 and 0.05 occupied nests/km respectively (0.056 occupied nests/km for Parsnip and Finlay Reaches combined).

4.1.3 Clutch Size

Sixty-eight of the 76 occupied osprey nests were active and clutch sizes were obtained for 63 of these on the 10-11 June survey. The mean clutch size was 2.73 ± 0.08 eggs (n=63, range = 1-4 eggs; Table 4). Although average clutch size for river nests was higher than that for reservoir nests, it was not significantly higher (Mann-Whitney U-test: $z=-1.00$, $p=0.32$). For nests located within the Williston Reservoir, there were no significant differences in clutch sizes between reaches (t-test: $t=-0.51$, 57 df, $p=0.61$) and Arms (ANOVA: $F(4,54)=0.11$, $p=0.98$).

4.1.4 Productivity

Of the 114 nests, 67% (76) were occupied and 60% (68) were active. Fifty-one percent (39) of the occupied osprey nests were successful. The remaining 37 nests had either failed, had already fledged young, or the number of young could not be determined by the time of the osprey fledgling

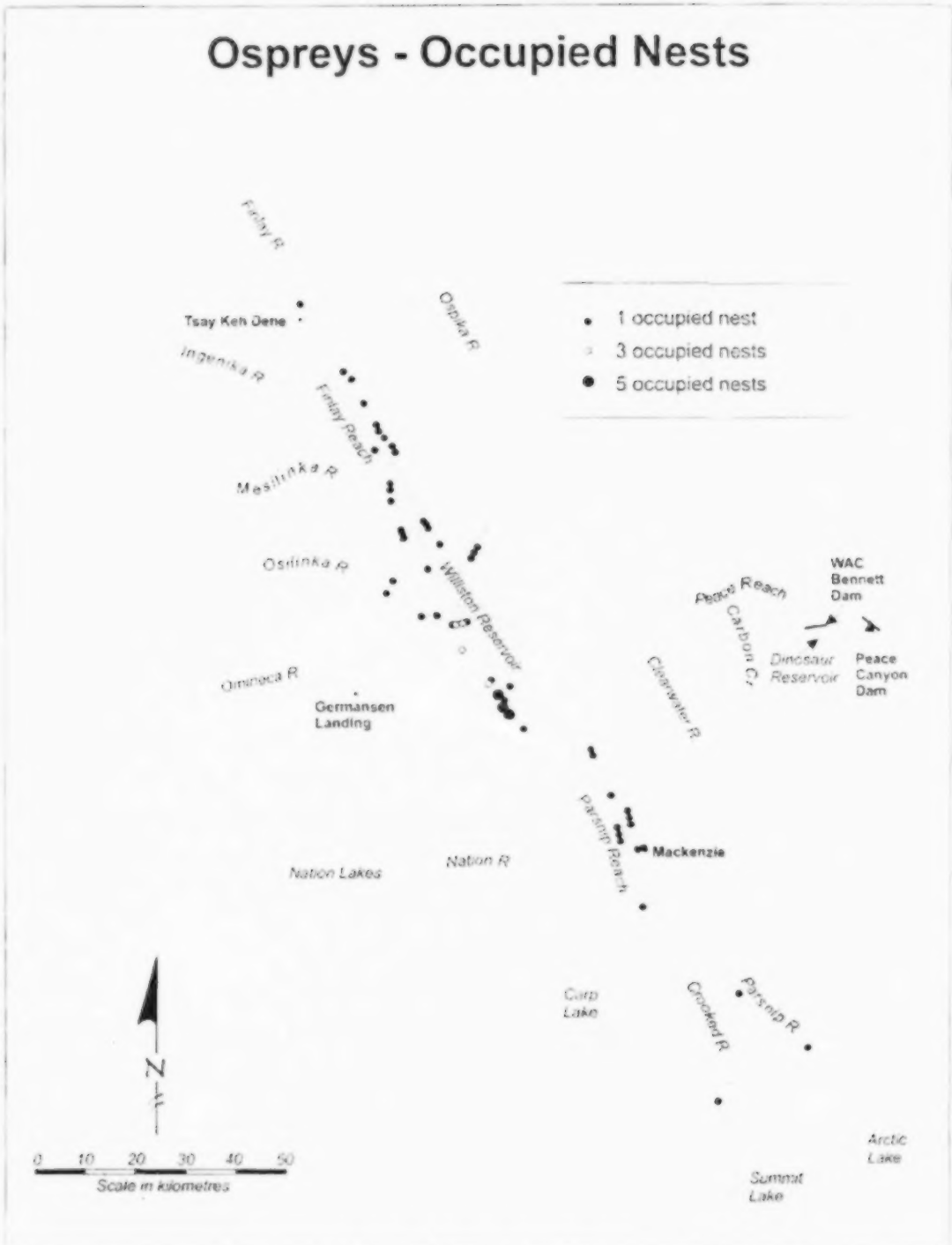


Figure 2. Distribution of occupied osprey nests within the 1997 study area.

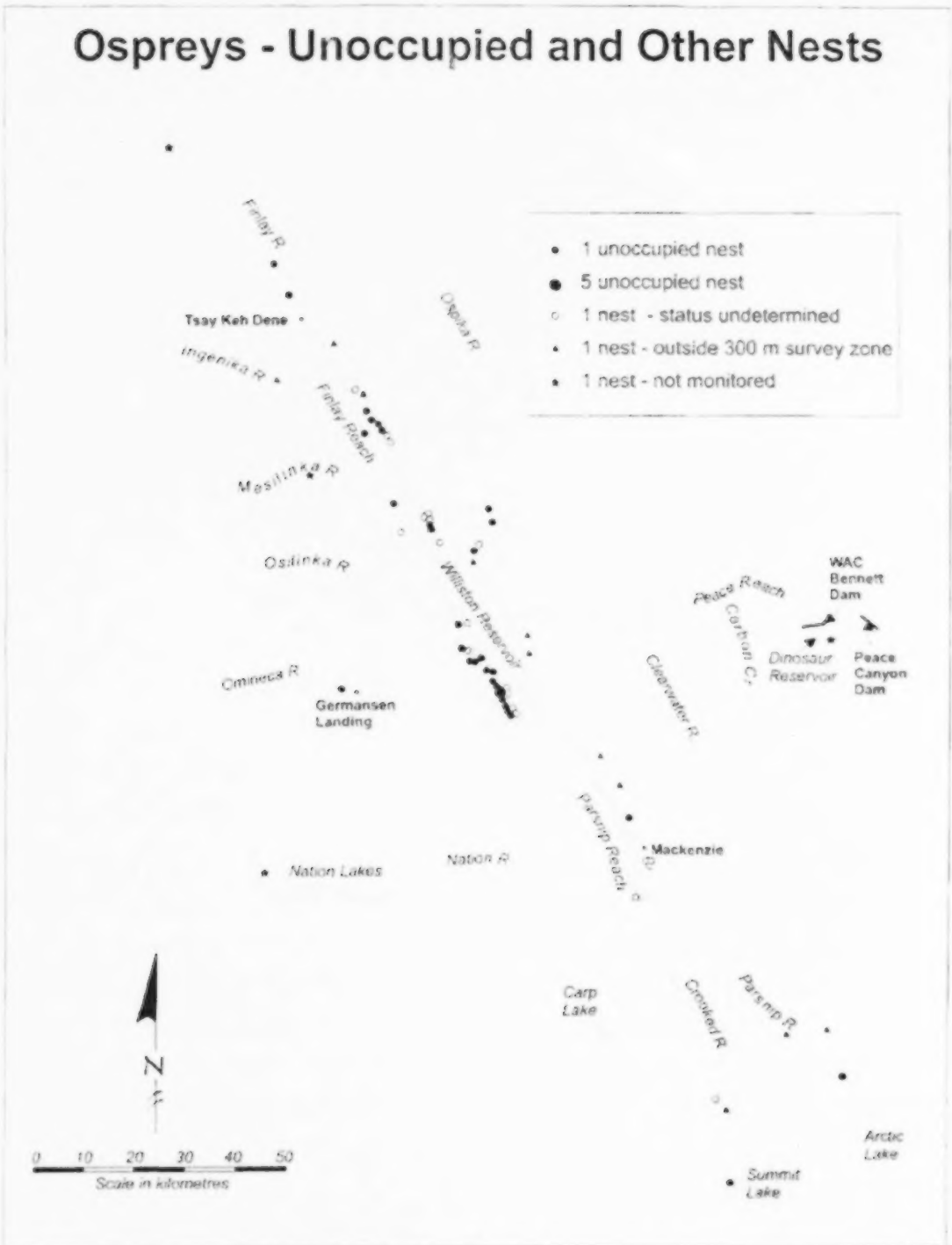


Figure 3. Distribution of unoccupied and other osprey nests within the 1997 study area.

Table 3. Distribution of occupied and unoccupied osprey nest sites located in 1997.

Area	occupied nests (n)	occupied nests (%)	unoccupied nests (n)	unoccupied nests (%)
Finlay Reach	**35**	**46**	**12**	**32**
Finlay Arm	20	26	9	24
Ospika Arm	3	4	2	5
Omineca Arm	12	16	1	3
Parsnip Reach	**37**	**49**	**20**	**53**
Parsnip Arm	17	23	5	13
Manson Arm	20	26	15	40
Peace Reach	**0**	**0**	**0**	**0**
Rivers	**4**	**5**	**5**	**13**
Lakes	**0**	**0**	**1**	**3**
TOTAL	**76**	**100**	**38**	**100**

Table 4. Mean clutch sizes for breeding ospreys in the Williston Reservoir watershed.

Area	nests (n)	mean clutch size	SE
RESERVOIR TOTAL	**59**	**2.71**	**0.08**
Finlay Reach	**27**	**2.67**	**0.12**
Finlay Arm	15	2.67	0.19
Ospika Arm	3	2.67	0.33
Omineca Arm	9	2.67	0.17
Parsnip Reach	**32**	**2.75**	**0.11**
Parsnip Arm	15	2.80	0.14
Manson Arm	17	2.71	0.17
Peace Reach	**0**	-	-
RIVERS	**4**	**3.00**	**0.00**
LAKES	**0**	-	-
TOTAL	**63**	**2.73**	**0.08**

survey. Osprey productivity within the survey area is estimated to be 1.12 ± 0.14 young/occupied nest, and 2.18 ± 0.13 young/successful nest (Table 5). Productivity of occupied nests was not significantly different between rivers and the reservoir (t=1.02, 74 df, p=0.31). Productivity of successful nests could not be statistically compared between river and reservoir nests because there was only one successful river nest. Productivity between the Finlay and Parsnip Reaches was 1.54± 0.22 and 0.78 ± 0.18 young/occupied nest, and 2.35 ± 0.16 and 1.93 ± 0.23 young/successful nest, respectively. Productivity of occupied osprey nests in the Finlay Reach was significantly higher than in the Parsnip Reach (t=2.68, 70 df, p=0.009), while no significant difference was noted for successful nests (t=1.52, df=36, p=0.14). There was no difference in productivity between reservoir Arms (occupied nests: ANOVA - $F_{(3,68)}$=1.72, p=0.17; successful nests: ANOVA - $F_{(3,34)}$= 1.98, p=0.14). Ospika Arm was excluded from this analysis because only 3 occupied nests occurred there relative to the 12 - 20 nests found in the other Arms of the Finlay and Parsnip Reaches. The maximum possible nest failure rates within the reservoir (includes percent of occupied nests that did not produce young, or young had fledged prior to survey) ranged from 0% in the Ospika Arm to 68% in the Parsnip Arm (Table 5). The maximum possible failure rate for river nests was 75%. Productivity of occupied nests for colonially nesting ospreys within the reservoir (n=24, mean = 1.21 ± 0.25) was not significantly different than for non-colonial ospreys within the reservoir (n=45, mean = 1.22 ± 0.19) (t=0.04, 68 df, p=0.97). Productivity of occupied and successful osprey nests located along the reservoir in 1995 was not significantly different than in 1997 (Table 6).

4.1.5 Nest Tree Characteristics

Osprey nests were found primarily in snags of unknown species (61% of occupied and 47% of unoccupied nests). These nest trees could not be identified to species during survey flights because they were emergent snags with no recognizable specific features. They typically consisted of one stem or a stem with a few branches left and were free of all foliage and bark. Occupied osprey nests identifiable to species consisted of 57% conifers and 43% cottonwoods. Unoccupied nests identifiable to species consisted of 70% conifers and 30% cottonwoods. One occupied osprey nest was found on an artificial nesting platform.

Physical condition and location relative to water of osprey nest trees in the reservoir varied little (Figures 4a,b). The majority of both occupied (87%, n=71) and unoccupied (81%, n=37) nest trees were in advanced stages of decay (classes 4, 5, & 6) (Figure 4a), and were found in or within 50 m of the inundation zone (occupied: 85%, n=72, unoccupied: 86%, n=37) (Figure 4b).

Table 5. Mean number of osprey young produced per occupied and successful nest in the Williston Reservoir watershed in 1997.

Area	Occupied nest			Successful nest			Max. nest failure
	n	mean	se	n	mean	se	rate (%)
RESERVOIR TOTAL	**72**	**1.15**	**0.15**	**38**	**2.18**	**0.14**	**47**
Finlay Reach	**35**	**1.54**	**0.22**	**23**	**2.35**	**0.16**	**34**
Finlay Arm	20	1.50	0.28	14	2.14	0.23	30
Ospika Arm	3	2.67	0.33	3	2.67	0.33	0
Omineca Arm	12	1.60	0.45	6	2.67	0.21	50
Parsnip Reach	**37**	**0.78**	**0.18**	**15**	**1.93**	**0.23**	**60**
Parsnip Arm	17	0.84	0.30	6	2.33	0.33	65
Manson Arm	20	0.75	0.23	9	1.67	0.29	55
Peace Reach	**0**	-	-	**0**	-	-	-
RIVERS	**4**	**0.50**	**0.50**	**1**	**2.00**	-	**75**
LAKES	**0**	-	-	**0**	-	-	-
TOTAL	**76**	**1.14**	**0.14**	**39**	**2.23**	**0.13**	**49**

Table 6. Comparison of 1995 and 1997 osprey productivity for nests around the Williston Reservoir.

Nest status	1995*			1997			t-test		
	n	mean	S.E.	n	mean	S.E.	t	df	p
Occupied	87	1.18	0.13	72	1.15	0.15	0.16	157	0.87
Successful	48	2.15	0.10	38	2.18	0.14	-0.23	84	0.82

*data from Booth et al. 1999

Characteristics of occupied nest trees in the Finlay Reach of the reservoir varied more than in the Parsnip Reach (Figures 5a,b). The distribution of decay classes for occupied osprey nests within the Parsnip Reach was significantly different than that for the Finlay Reach (Figure *5a*, $X^2=13.3$, 2 df, $p<0.01$), with Parsnip Reach nests exclusively in decay classes 4, 5, and 6, and Finlay Reach nests distributed across all classes. Although the majority of occupied nest trees were found within the inundation zone, a significantly lower proportion of nest trees in the Finlay Reach were located within the inundation zone compared to the Parsnip Reach (Fig 5b; $X^2=18.3$, 2 df, $p<0.001$). Overall, 79% and 92% of occupied osprey nest trees were in or within 50 m of the inundation zone in the Finlay and Parsnip Reaches, respectively.

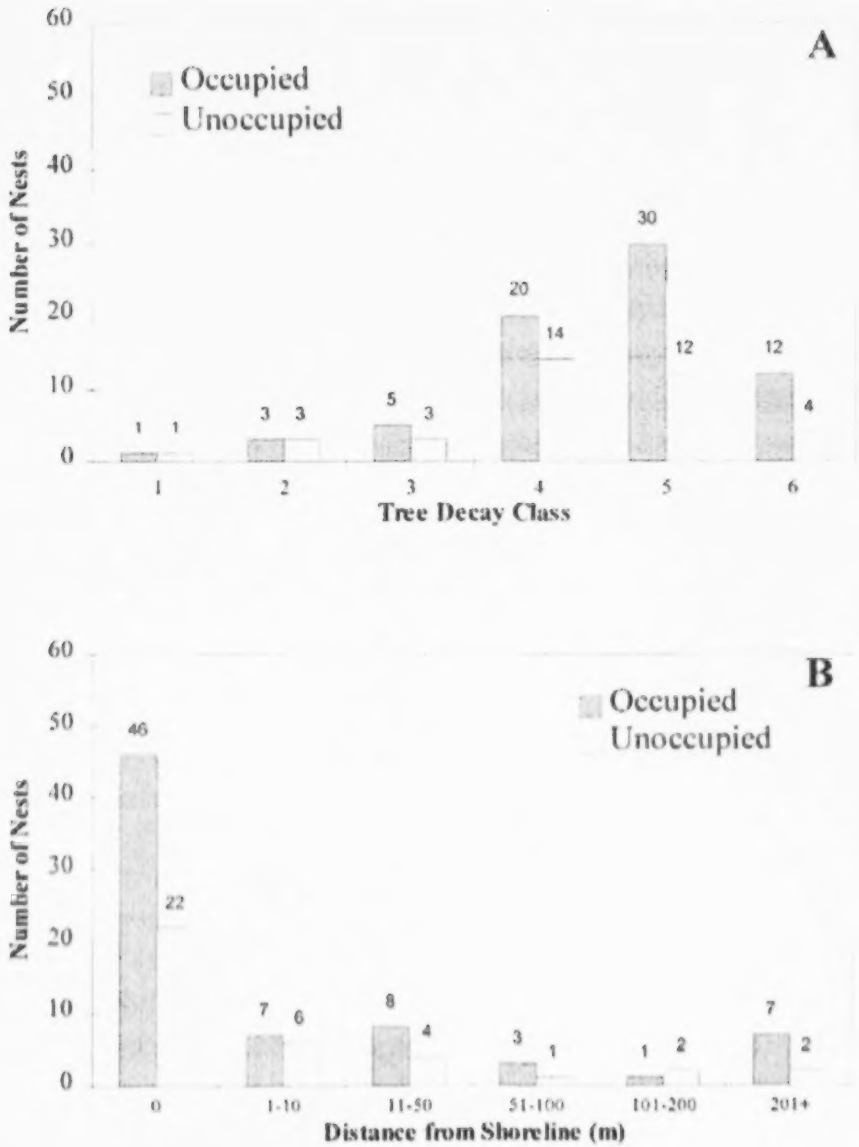


Figure 4. Number of occupied and unoccupied osprey nests by (A) tree decay class and (B) distance from water for nests within the study area during 1997. Numbers at top of bars represent number of nests in each category.

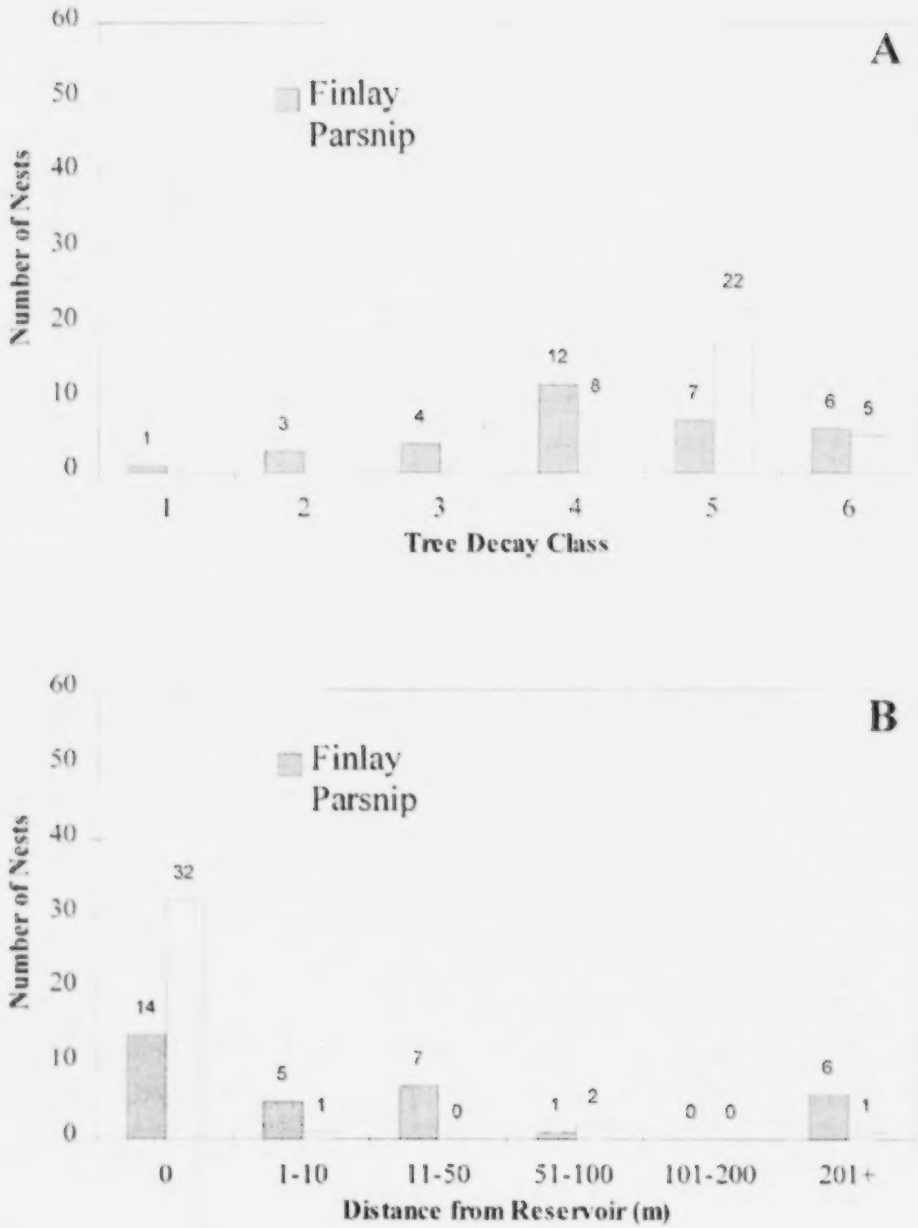


Figure 5. Number of occupied osprey nests by (A) tree decay class and (B) distance from water for nests within the Finlay and Parsnip Reaches of the Williston Reservoir during 1997. Numbers at top of bars represent number of nests in each category.

4.1.6 Nest Attrition and Flooding

Between surveys conducted around the Williston Reservoir perimeter in 1995 and 1997, 28% (31) of the osprey nests documented in 1995 were lost due to tree failure, nest destruction, or nest collapse (Figure 6); 58% of these nests had been occupied in 1995. Of the 79 osprey nests located in 1995 that were not lost, 61% (48) were used by nesting birds in 1997. During the 1997 breeding season, 5 osprey nests failed due to flooding, nest destruction or tree failure. Three nests on emergent snags that were barely above water and contained eggs during the occupancy survey on June 10/11, had been flooded by the August 11/12 fledgling survey. Two of these nests were in Manson Arm, and one was in a small bay to the north. The other two nests were outside of the inundation zone; they could not be located during the fledgling survey and were presumed to have fallen.

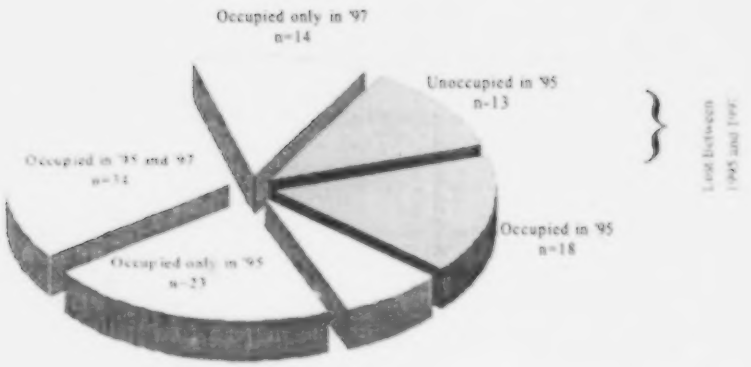


Figure 6. Fate of 110 osprey nests found around the Williston Reservoir during the 1995 survey season and resurveyed in 1997.

4.2 Bald Eagles

4.2.1 Timing of Clutch Initiation

Twenty-seven (27) bald eagle nests were visited during two clutch initiation surveys. On 10 April, 44% (12) of the nests were attended by at least 1 adult, 4 of which had at least 1 egg. By 25 April, 63% (17) of the nests were attended by adults, 52% (14) had at least 1 egg and 37% (10) had 2 eggs. This suggested that the majority (82%) of the potentially occupied bald eagle nests in the study area had initiated clutches by the 3rd week of April.

4.2.2 Nest Site Density and Distribution

During the 1997 surveys, 142 bald eagle nest sites were recorded; 139 of these were used for analyses. Of the 3 nests excluded from analyses, 1 was incidentally observed outside the 300-m search zone from a waterway edge, 1 was located within the search zone but was geographically isolated from the majority of the bald eagle nests so that data collection for this nest was not cost effective, and 1 nest site collapsed prior to the eagle occupancy survey flight. Of the 139 nests, 47% (66) were determined to be occupied.

Occupied and unoccupied bald eagle nests were distributed along the shorelines of the rivers, lakes, and both reservoirs surveyed (Figure 7, 8; Table 7). One/third of the occupied nests were located along rivers, with relatively equal distribution between the three reservoir reaches, while almost half of the unoccupied nests were located on rivers. The minimum breeding bald eagle density was 0.02 breeding pairs/km of reservoir shoreline, 0.02 breeding pairs/km of river, and 0.03 breeding pairs/km of lake shoreline.

4.2.3 Clutch Size

Sixty-one (61) of the 66 occupied bald eagle nests were active, and clutch sizes were obtained from all of them during the 5-7 May occupancy surveys. The mean clutch size was 1.90± 0.04 eggs/nest (n=61, range 1-2 eggs) (Table 8). Average clutch sizes for reservoir, river, and lake nests were not significantly different (Kruskal-Wallis 1-way ANOVA: X^2=3.34, 2 df, p=0.19). Amongst reservoir nests, there were no significant differences in clutch sizes between reaches (Kruskal-Wallis 1-way ANOVA: X^2=2.24, 2 df, p=0.33).

4.2.4 Productivity

Of the 139 nests included in the analyses, 47% (66) were occupied and 44% (61) were active. Fifty percent (33) of the occupied eagle nests were successful. The remaining 33 nests had either

Figure 7. Distribution of occupied bald eagle nests within the 1997 study area.

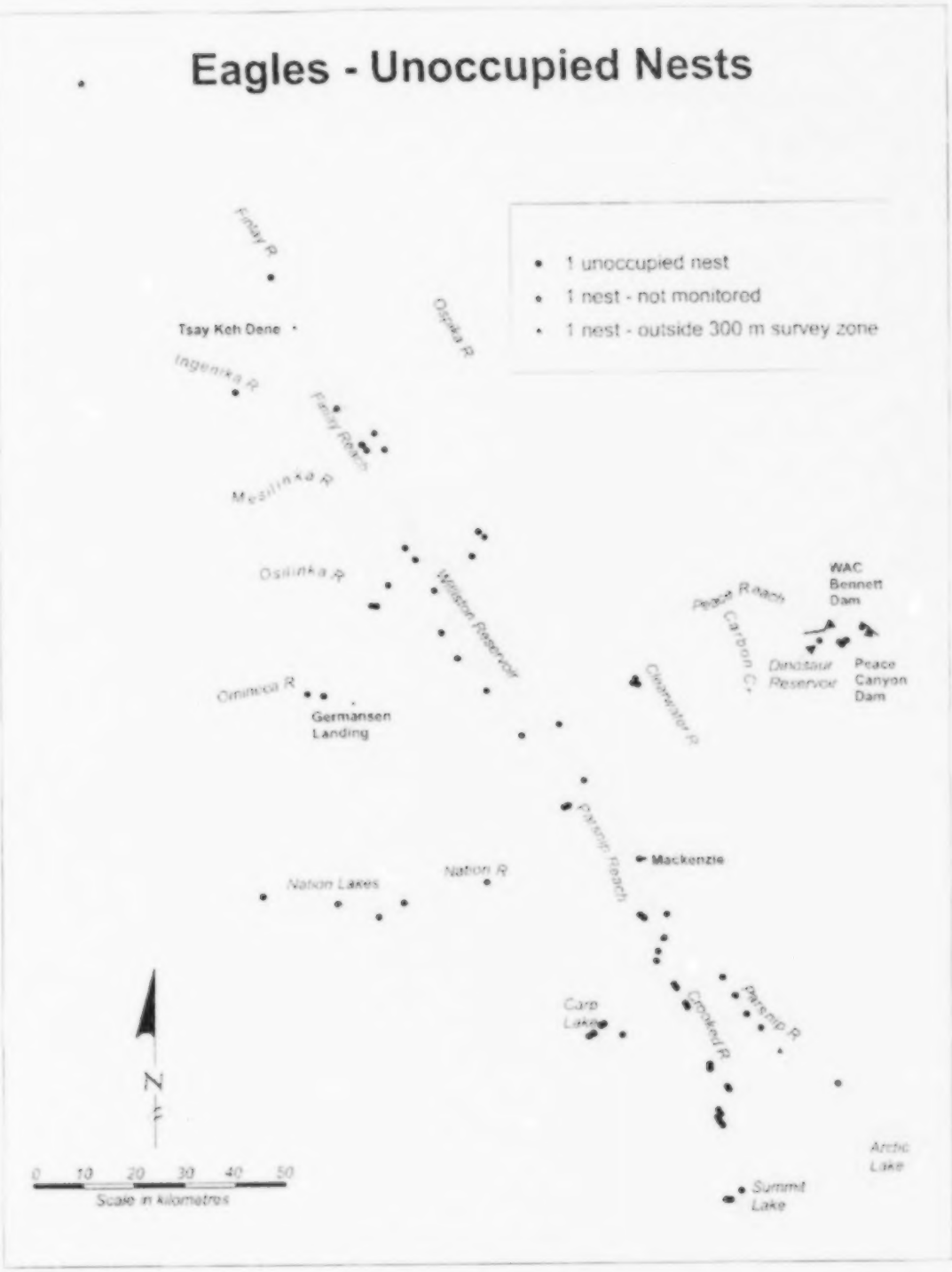


Figure 8. Distribution of unoccupied bald eagle nests within the 1997 study area.

Table 7. Distribution of occupied and unoccupied bald eagle nest sites surveyed in 1997.

	occupied nests (n)	occupied nests (%)	unoccupied nests (n)	unoccupied nests (%)
Finlay Reach	**12**	**18**	**12**	**16**
Finlay Arm	10	15	9	12
Ospika Arm	1	2	3	4
Omineca Arm	1	2	1	0
Parsnip Reach	**14**	**21**	**10**	**14**
Parsnip Arm	12	18	8	11
Manson Arm	2	3	1	3
Peace Reach	**11**	**17**	**5**	**7**
Peace Arm	8	12	0	0
Dinosaur Reservoir	3	5	5	7
Rivers	**22**	**33**	**35**	**48**
Lakes	**7**	**11**	**11**	**15**
TOTAL	**66**	**100**	**73**	**100**

Table 8. Mean clutch size for breeding bald eagles the Williston Reservoir watershed.

Area	nests (n)	mean clutch size	SE
RESERVOIR TOTAL	**33**	**1.91**	**0.04**
Finlay Reach	**11**	**1.82**	**0.12**
Finlay Arm	9	1.89	0.11
Ospika Arm	1	1.00	-
Omineca Arm	1	2.00	-
Parsnip Reach	**12**	**2.00**	**0.00**
Parsnip Arm	12	2.00	0.00
Manson Arm	2	2.00	0.00
Peace Reach	**12**	**1.90**	**0.10**
Peace Arm	7	2.00	0.00
Dinosaur Res.	3	1.67	0.33
RIVERS	**21**	**1.95**	**0.05**
LAKES	**7**	**1.71**	**0.18**
TOTAL	**61**	**1.90**	**0.04**

failed, had already fledged young, or the number of young could not be determined by the time of the third aerial survey.

Bald eagle productivity within the survey area is estimated to be 0.71 ± 0.10 young/occupied nest, and 1.42 ± 0.09 young/successful nest (Table 9). Productivity was not significantly different between occupied nests located along rivers, lakes and the reservoir (Kruskal-Wallis 1-way ANOVA: X^2=2.42, 2 df, p=0.30), however, productivity of successful nests was affected by the type of water body with which they were associated. Productivity of successful nests appeared to be higher amongst reservoir nests compared to river or lake nests (Kruskal-Wallis 1-way ANOVA: X^2=6.67, 2 df, p=0.03). Bald eagle productivity was not significantly different for occupied or successful nests between the Finlay, Parsnip and Peace Reaches (ANOVA occupied nests $F_{(2,34)}$=0.06, p=0.95; successful nests $F_{(2,17)}$=0.17, p=0.85). Possible bald eagle nest failure rates within the reservoir ranged from 0% in the Omineca and Manson Arms to 100% in the Ospika Arm (Table 9). Failure rates amongst nests located along rivers and lakes was 59% and 29%, respectively. There was no difference in productivity for eagle nests located along rivers between the two biogeoclimatic zones included in this survey (SBS, n=17, mean = 0.47 ± 0.15; BWBS, n=5, mean = 0.80 ± 0.37; t=-0.96, 20 df, p=0.35). Productivity of occupied and successful bald eagle nests located along the reservoir in 1995 was not significantly different from that in 1997 (Table 10).

4.2.5 Nest Tree Characteristics

Nest trees selected by bald eagles for nesting within the survey area were typically sound deciduous trees within 100 m of water (Figures 9a,b,c). Bald eagles selected primarily trembling aspen and cottonwood trees for nesting (88%) (Figure 9a). Nest trees tended to be sound (92% of occupied, and 100% of unoccupied bald eagle nest trees in decay classes 1, 2, and 3) (Figure 9b), and within 100 m of water (85% and 97% of occupied and unoccupied bald eagle nests respectively) (Figure 9c).

Although generally similar, occupied bald eagle nest tree characteristics varied somewhat between reservoir, river and lake nests (Figures 10a,b,c). Nest trees were predominately deciduous in all three site types, however, Douglas-fir was used as a nesting substrate along the Crooked River. Unoccupied nests were also found in this tree species around Summit Lake. Douglas-fir does not occur along the reservoirs' perimeters, or the margins of the northern rivers or lakes. Unlike occupied nest trees located along the reservoir and rivers which were in decay classes 1-4, occupied nests along lake margins occurred exclusively in trees of decay class 1 (Figure 10b). There were no significant differences in distributions of decay classes between reservoir and river nest sites

(X^2=0.38, 2 df, p>0.90). A greater proportion of nests located along the reservoir margin tended to be within 50 m of water relative to those along rivers or lakes (81% reservoir, 59% river, 43% lake; Figure 10c).

Occupied nest trees in the reservoirs showed some variation between the reaches (Figures 11a,b,c). Nests in deciduous trees were split more or less evenly between cottonwoods and aspens in the Finlay and Peace Reaches, while in the Parsnip Reach, there were approximately 2.5 times as many nests in cottonwoods than in aspen (Figure 11a). Trees selected by bald eagles for nesting

Table 9. Mean number of bald eagle young produced per occupied and successful nest in the Williston Reservoir and nearby areas in 1997.

Area	Occupied nest			Successful nest			Max. nest failure rate (%)
	n	mean	se	n	mean	se	
RESERVOIR TOTAL	**37**	**0.86**	**0.15**	**20**	**1.60**	**0.11**	**46**
Finlay Reach	**12**	**0.83**	**0.27**	**6**	**1.67**	**0.21**	**50**
Finlay Arm	10	0.80	0.29	5	1.60	0.24	50
Ospika Arm	1	0.00	-	0	-	-	100
Omineca Arm	1	2.00	-	1	2.00	-	0
Parsnip Reach	**14**	**0.93**	**0.25**	**8**	**1.62**	**0.18**	**43**
Parsnip Arm	12	0.75	0.25	6	1.50	0.22	50
Manson Arm	2	2.00	0.00	2	2.00	0.00	0
Peace Reach	**11**	**0.82**	**0.26**	**6**	**1.50**	**0.22**	**45**
Peace Arm	8	1.00	0.33	5	1.60	0.24	38
Dinosaur Res.	3	0.33	0.33	1	1.00	-	67
RIVERS	**22**	**0.55**	**0.14**	**9**	**1.22**	**0.15**	**59**
LAKES	**7**	**0.71**	**0.18**	**5**	**1.00**	**0.00**	**29**
TOTAL	**66**	**0.71**	**0.10**	**33**	**1.42**	**0.09**	**50**

Table 10. Comparison of 1995 and 1997 bald eagle productivity for nests around the Williston Reservoir.

Nest status	1995*			1997			t-test		
	n	mean	S.E.	n	mean	S.E.	t	df	p
Occupied	36	0.86	0.13	37	0.86	0.15	-0.02	71	0.99
Successful	23	1.35	0.10	20	1.60	0.11	-1.67	41	0.10

*data from Booth et al. 1999

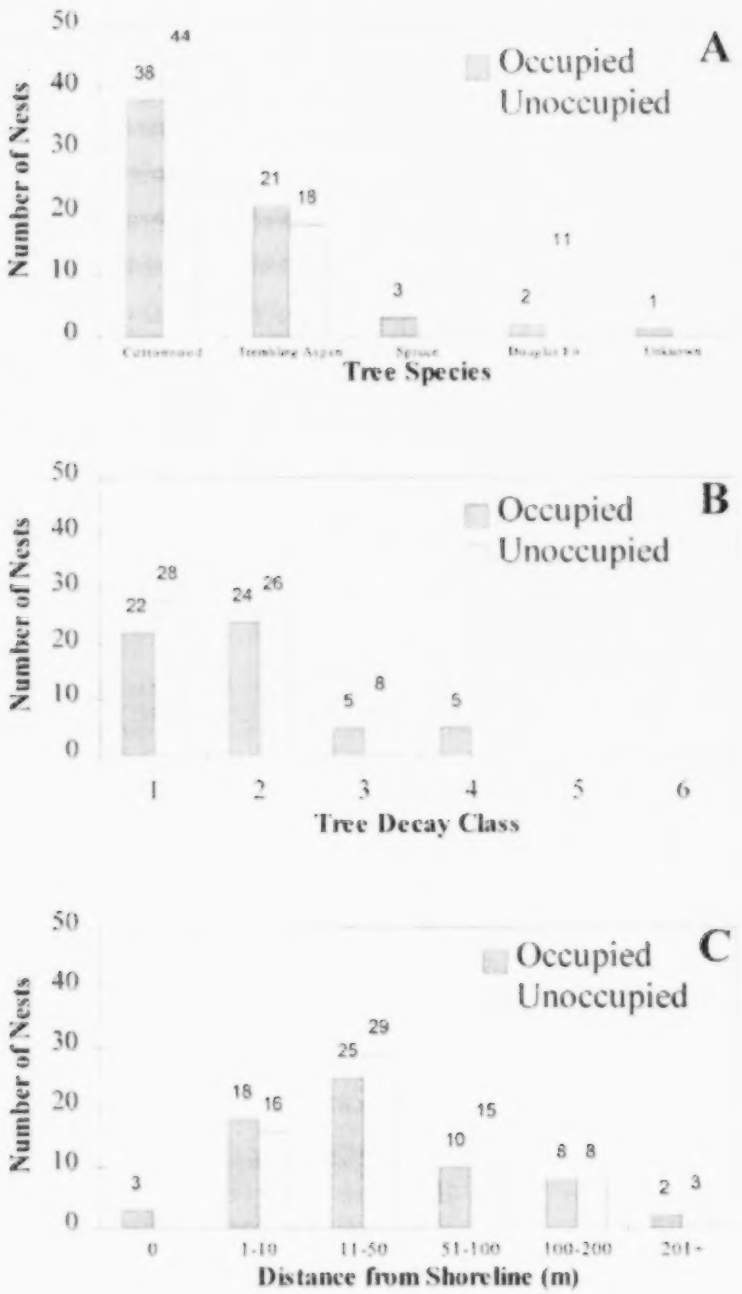


Figure 9. Number of occupied and unoccupied bald eagle nests by (A) tree species, (B) tree decay class and (C) distance from water for nests within the study area during 1997. Numbers at top of bars represent number of nests in each category.

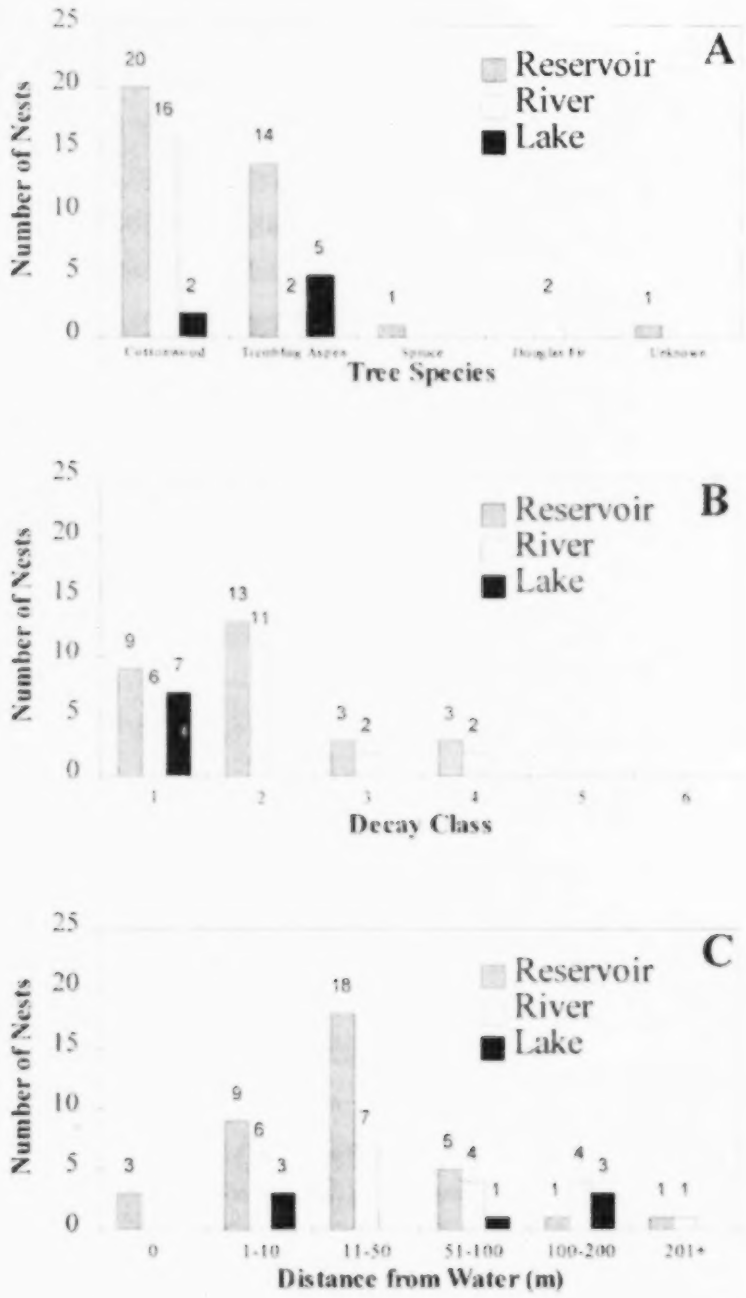


Figure 10. Number of occupied bald eagle nests by (A) tree species, (B) tree decay class and (C) distance from water for reservoir, river and lake nests found during 1997. Numbers at top of bars represent number of nests in each category.

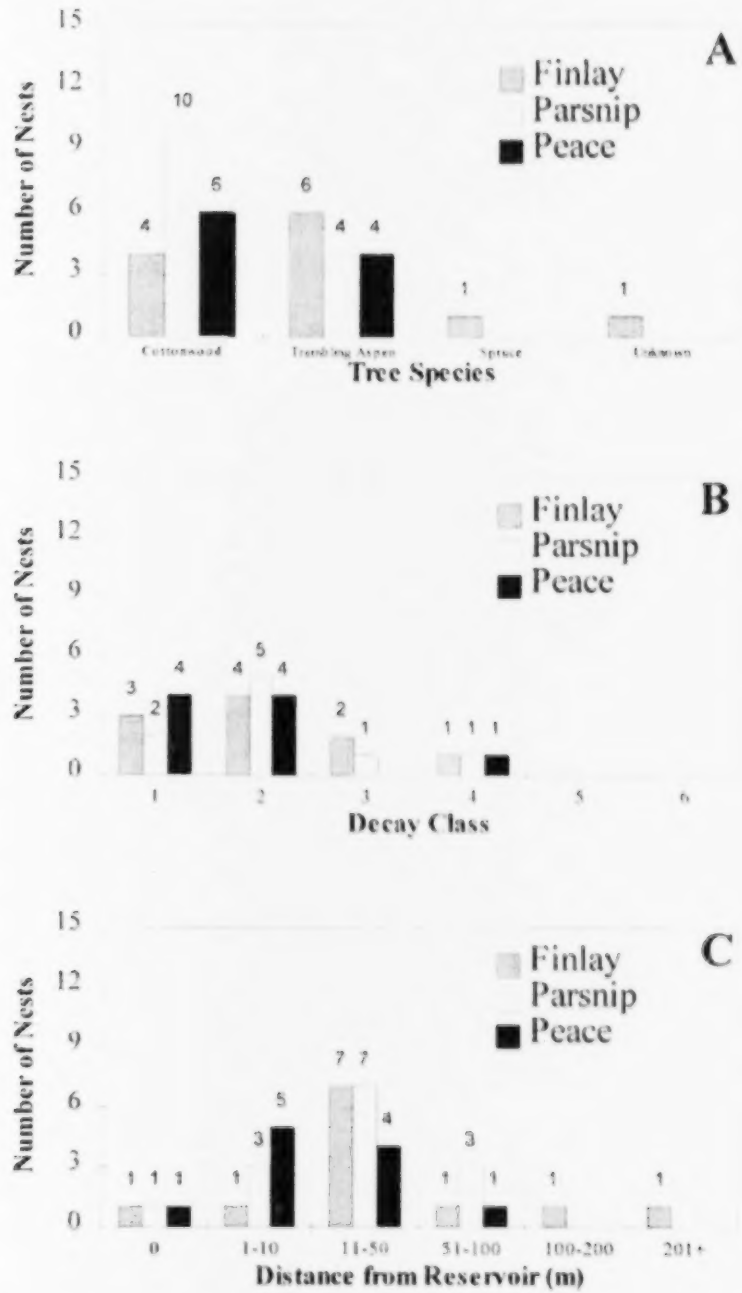
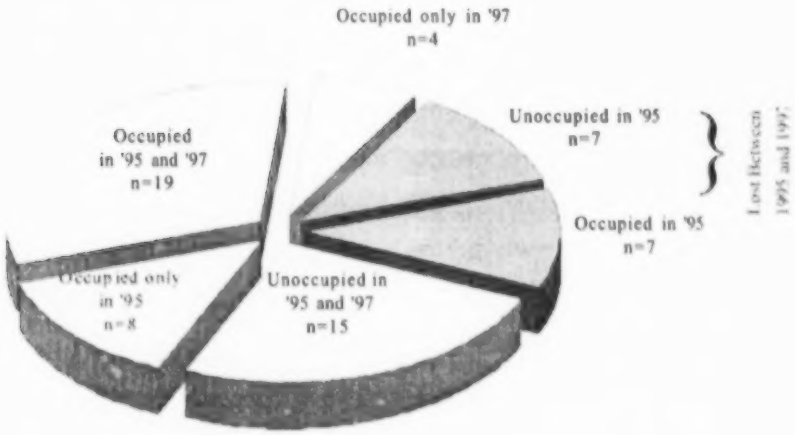


Figure 11. Number of occupied bald eagle nests by (A) tree species, (B) tree decay class and (C) distance from water for nests within the Finlay, Parsnip and Peace Reaches of the Williston Reservoir during 1997. Numbers at top of bars represent number of nests in each category.

tended to be relatively sound in all reservoir reaches (Figure 11b), and the distribution of distance from water classes for nests did not differ significantly in any pairwise comparison of the three reaches (X^2-tests: Finlay-Parsnip - X^2=0.75, 3 df, p>0.80); Peace-Parsnip - X^2=1.86, 3 df, p>0.60; Peace-Finlay -X^2=5.61, 3 df, p>0.10) (Figure 11c).

4.2.6 Nest Attrition

Between surveys conducted around the Williston Reservoir perimeter in 1995 and 1997, 23% (14) of the bald eagle nests surveyed in 1995 were lost due to tree failure, nest destruction, or nest collapse (Figure 12); 50% of these had been occupied in 1995. Of the 46 nests located in 1995 that were not lost, 50% (23) were occupied in 1997. No occupied bald eagle nests were physically lost



during 1997, with the exception of one nest that collapsed prior to the eagle occupancy surveys.

Figure 12. Fate of 60 bald eagle nests found around the Williston Reservoir during 1995 survey season and resurveyed in 1997.

5.0 DISCUSSION

5.1 Ospreys

5.1.1 Clutch Initiation Dates

Establishing reasonably accurate clutch initiation dates is extremely important in scheduling clutch size and productivity surveys. Limited data on expected egg laying dates for osprey were available for areas north of Prince George, B.C. prior to this study (Campbell et al. 1990). The preliminary clutch initiation flights were extremely useful in determining the timing of subsequent surveys. From our data it is evident that clutch initiation dates for bald eagles and ospreys are considerably different and that separate surveys were warranted during the 1997 survey season.

Timing of osprey arrival and clutch initiation is likely linked to spring temperature gradients more than latitude in the northern hemisphere. In general, egg laying occurs later in the breeding season in areas where rivers and lakes remain ice covered for longer periods of time. Breeding ospreys lay eggs as early as mid-March in Chesapeake Bay (36° N latitude) (Reese 1977), but do not start laying until mid-May in Labrador (54° N latitude) (Wetmore and Gillespie 1976). Although ospreys in Scotland (57-58° N latitude) are marginally further north than those in Labrador, they have been documented to start laying eggs about a month earlier presumably due to the effect of warm ocean currents along the coast of the British Islands (Green 1976 as cited in A. Poole 1989). Ospreys nesting within the Williston Reservoir area likely lay later in the year than other populations further south or closer to the coast. Steeger and Ydenberg (1993) reported clutch initiation dates as early as late April/early May for populations found in southeastern British Columbia. Our earliest confirmed date for ospreys was 16 May, at least 2 weeks later.

5.7.2 *Nest Site Density and Distribution*

Differences in the coarse habitat types (coastal, interior lake, reservoir, interior river) and in the way that osprey breeding densities are reported in the literature make comparisons to other populations difficult (Table 11). The density of ospreys nesting along the shoreline of the Williston Reservoir itself is at least 5.5 times greater than populations surveyed in central British Columbia in 1997 (K.G. Poole, 1997). However, these surveys concentrated on rivers and natural lake systems within the Ft. St. James Forest District in northcentral B.C., covering 1,233 km of shoreline and linear river distance combined. Poole's densities are more consistent with the densities derived from our river surveys in 1997. When compared with a reservoir in Montana (0.22 pairs/km, Grover 1984) and the Nechako Reservoir near Smithers where in some areas occupied osprey nests had densities in

excess of 3 nests/km of shoreline (Lloyd 1997), the Williston Reservoir osprey nesting density is low. Although the density of ospreys within the Williston Reservoir is as high as 5 per km where colonies occur, the affected area is very small relative to the entire reservoir. One notable result from our surveys is that no osprey nests were located in the Peace Arm of the reservoir.

Given that the Williston Reservoir osprey population has a density that is 10 times greater than those located along rivers during this survey and 5.5 times that found along natural lakes and rivers by K.G. Poole (1997), it is likely that the Williston Reservoir osprey population has significantly increased in size since reservoir impoundment. A. Poole (1989) suggested that breeding density is controlled to a great extent by the availability of stable, predator free nest sites. Water management that leads to flooding often results in the isolation of standing trees that appear to attract nesting ospreys presumably for the security from predation that they provide (Henny and Noltmeier 1975, Hagan 1984 as cited in A. Poole 1989). Emergent snags along the Parsnip and Finlay Reaches of the Williston Reservoir provide many such sites for nesting ospreys and may be contributing to a larger osprey population than was present prior to impoundment. The steep terrain of the Peace Reach resulted in fewer emergent snags being present which likely contributes to the lack of nests in this reach.

Table 11. Osprey breeding densities from this (italicized text) and other studies in North America.

Habitat	Occupied nest density	Location	Authority
Reservoirs			
Canyon Ferry Reservoir	0.41 nests/km shoreline	Montana	Grover 1984
Nechako Reservoir	0-3 pairs/km shoreline	northcentral BC	Lloyd 1997
Williston Reservoir	0.05 pairs/km shoreline	northcentral BC	Booth et al. 1999
Williston Reservoir	*0.04 pairs/km shoreline*	*northcentral BC*	*This report*
Rivers			
rivers	0.03 pairs/km shoreline	Montana	Grover 1984
rivers	*0.004 pairs/km shoreline*	*northcentral BC*	*This report*
Lakes			
lakes and rivers combined	0.0073 pairs/km shoreline	northcentral BC	K.G. Poole 1997
Unknown			
unknown	0.41 pairs/100 km^2	Quebec	Bider and Bird 1983
unknown	1.2 pairs/100 km^2	Quebec	Wetmore and Gillespie 1976

5.1.3 Colonial Nesting in Ospreys

No clear definition of conditions representing colonial nesting has been presented for ospreys in the literature, however, it is recognized that in some instances, numerous ospreys (as many as 300, Greene 1987) nest in close proximity to each other and function as a colony. Flemming et al. (1991) determined that for ospreys nesting in an estuary in Antigonish County, Nova Scotia, mean internest distance for colonial nesters was 700 m and that some nests were as close as 300 m to the nearest conspecific nest. For the colonies found in the Williston Reservoir, osprey internest distances were as short as 50 m.

Although there is some speculation as to why colonial nesting evolved in ospreys, it is evident that there are many adaptive advantages associated with it. Colonially nesting species often experience reduced losses to predation (Hagan and Walters 1990). Flock foraging can improve foraging success and gains in foraging efficiency can lead to improved productivity (Flemming et al. 1991). For ospreys, the recruitment of flock mates for social foraging, and hence the benefits of social foraging is more likely in colonially nesting ospreys (Flemming et al. 1991). Colonial breeding and associated flock foraging are particularly adaptive when prey occur in clumped distributions (Greene 1987). These situations occur when fish species school, spawn or use forage sources that are clumped. From our data no apparent advantage in terms of increased productivity was found for colonially nesting ospreys. It is unclear if and how the osprey colonies within the Williston Reservoir benefit from colonial nesting or whether colonial nesting is an artifact of nest site availability (emergent snags tend to have a clumped distribution within the reservoir) or variations in local prey abundance.

5.1.4 Clutch size

Lack (1968) first postulated that, in general, birds breeding at higher latitudes tend to have larger clutches than those in southern climates. Given this, we would expect that the Williston population of ospreys would have slightly higher clutch sizes than areas to the south in the U.S. The mean clutch sizes for ospreys in the Williston study area (mean = 2.73) is, in fact, similar to those reported elsewhere. Several populations on the east coast of North America had larger clutch sizes (Massachusetts: mean = 3.3 [A. Poole 1984 as cited in K.G. Poole 1989]; New York: mean=3.2 [A. Poole 1982]), while some in more southern climates were in the same range (California: mean = 2.8 [Judge 1983]; Florida - mean = 2.7 [A. Poole 1982]; Michigan - mean = 2.98 [Postupalsky 1985 as cited in A. Poole 1989]). Clutch sizes reported for areas in northcentral BC were higher in the Ft. St. James Forest District (mean = 3.00; K.G. Poole 1997), and lower in the Vanderhoof Forest District

(mean = 2.00; K.G. Poole 1998) than the Williston estimates, although sample sizes were quite small (n=3 Ft. St. James, n=1 1 Vanderhoof). It should be noted that our estimate of clutch size is based on two nest initiation surveys that occurred relatively early in the breeding season. Additional eggs laid after these flights are not included, therefore, our estimates should be considered as minimum clutch sizes for ospreys nesting near the Williston Reservoir.

5.1.5 *Productivity*

Our estimate of osprey productivity based on young/successful nest is high compared to other North American populations (Table 12). Our minimum productivity estimate based on young/occupied nest falls in the middle of the range reported from other studies, as does our maximum estimate of nest failure rates. We assumed that all nest sites lacking fledgling data represented nest failures, thus our young/occupied nest estimate represents the lowest possible productivity. Comparisons between some of the data reported in Table 12 and our data should be made with caution. Much of the historical data from other North American osprey populations was collected at a time when many of these populations were recovering from various human-induced declines. Productivity of the Williston watershed osprey population is either greater than or very similar to more recently surveyed populations (USDA Forest Service 1988, Hagan and Walters 1990, Steeger et al. 1992, K.G. Poole 1997).

Henny and Wight (1969) estimated that to be stable, a population of nesting ospreys should fledge between 0.95 and 1.30 young/breeding pair/year based on an analysis of mortality rates in several northeastern US populations. Our lowest productivity estimate of 1.19 young/occupied nest fits well within this range, suggesting a relatively stable population. However, mortality rates for the Williston Reservoir ospreys may not be equivalent to those determined by Henny and Wight (1969); rates may be higher for Williston ospreys as they must migrate greater distances to wintering grounds than those studied in the eastern U.S. Productivity rates in excess of 1.30 young/breeding pair/year may be required to provide for a stable or growing population in Northcentral BC. Ospreys breeding in Finland (60° - 70° N latitude) appeared to maintain a fairly stable population size between 1971 and 1980 with productivity rates of between 1.3 - 1.5 young per occupied/nest (Saurola 1983). Although Williston Reservoir is slightly farther south (between 55° and 57° N latitude) comparing the Williston population with the Finnish population may be more appropriate. At this stage, it is difficult to ascertain whether the Williston population is declining, stable, or growing.

Factors reported to affect osprey productivity (and density) include: limited food resources (A. Poole 1982, Kushlan and Bass 1983, Hagan 1986), inclement weather (MacCarter and MacCarter

Table 12. Osprey productivity and nest failure rate from this (italicized text) and other studies in North America.

Location	Year(s) data collected	Coastal or interior system (C or I)	Aquatic system[1]	Young per occupied nest	Young per successful nest	# of nests	% of nests that failed	Authority
Eastern Region	1980-1988	-	-	0.94	1.66	2080	43.7	USDA Forest Service 1988
New Jersey	1968-1975	C	O	0.31	1.43	297	78.0	Henny et al. 1977
Delaware	1970-1975	C	O	1.09	1.96	118	44.4	Henny et al. 1977
Nova Scotia	1975-1981	C	O	1.22	1.87	237	43.2	Seymour and Bancroft 1983
Alaska	1976-1980	C	O	1.42	2.12	12	30.4	Hughes 1982
Mexico	1977-1978	C	O	0.87	1.66	67	47.8	Judge 1983
New Jersey	1987-1988	C	O	1.21	1.69	62	32.3	Steidl et al. 1991
North Carolina	1983-1985	C	O,R	1.15	-	130	-	Hagan and Walters 1990
New Brunswick	1974-1980	C,I	O,R	1.10	1.80	133	39.0	Stocek and Pearce 1983
Southeastern BC	1981		L,R	1.50	-	27	-	Flook and Forbes 1983
Northcentral BC	1996		L,R	0.33	1.00	9	67	K.G. Poole 1997
Northcentral BC	1997		L,R	0.88	2.2	25	60	K.G. Poole 1998
Northcentral BC	*1997*	I	*R*	0.50	2.00	*4*	75	*This study*
Idaho	1978-1980		RE	1.27	2.00	144	32.0	Van Daele and Van Daele 1982
Montana	1981-1982		RE	1.12	2.16	83	48.2	Grover 1984
Southeastern BC	1987-1988		RE	1.40	2.10	162	29.2	Steeger et al. 1992
Northcentral BC	1995		RE	1.18	2.15	87	55.0	Booth et al. 1999
Northcentral BC	*1997*	I	*RE*	*1.15*	*2.18*	72	*47*	*This study*

[1] O=ocean, RE=reservoir, L=lake, R=river

1979, Van Daele and Van Daele 1982), disease (A. Poole 1989), interspecific competition (Ogden 1975, Hughes 1982), predation on eggs and chicks by corvids and owls (MacCarter and MacCarter 1979, Hughes 1982), human disturbance (Hughes 1982, Van Daele and Van Daele 1982, Levenson and Koplin 1984), environmental contamination (MacCarter and MacCarter 1979, Henny 1983) and the availability of nesting habitat (Rhodes 1972, Little 1994). Forage quality and foraging energetics have been identified as factors that can determine productivity of ospreys by some authors (Hagan 1986, A. Poole 1982) but these factors have been refuted by others (MacCarter and MacCarter 1979, Steeger et al. 1992).

Many of the above factors affect productivity by inducing egg failure (Levenson and Koplin 1984, Steidl et al. 1991). Egg viability can be affected through environmental contamination where eggshell thinning and altered gas exchange across shell surfaces and membranes ultimately leads to egg failure. Low hatching success can also be caused by insufficient or irregular incubation. Human activity in the vicinity of nests can prevent proper incubation of eggs by displacing birds from nests (Levenson and Koplin 1984) however, given the remote nature of most of the nests surveyed, it is unlikely that this would affect osprey productivity in the Williston Reservoir area. Harassment from other avian species can also negatively affect productivity: cervids and owls can harass ospreys to the point where hatching success is compromised (Levenson and Koplin 1984). No data are available to document such interspecific pressures on ospreys in the Williston Area.

Breeding chronology is thought to affect osprey productivity in more subtle ways. Initiation of reproduction early in the breeding season has been shown to result in greater fledgling production (Judge 1983, Steeger et al. 1992, Steeger and Ydenberg 1993). Initiation of clutches within the Williston osprey population is likely asynchronous across all nesting pairs. Variability in productivity within Williston Reservoir ospreys may be partially explained by this phenomenon.

5.1.6 Nest Site Characteristics

Ospreys nesting along the perimeter of the Williston Reservoir are selecting predominately dead deciduous or coniferous trees in close proximity to the reservoir shoreline as nest sites. The predominance of osprey nest sites in dead trees is consistent with other studies that have examined osprey nesting sites (Van Daele and Van Daele 1982, Smith and Ricardi 1983, Steeger et al. 1992, Lloyd 1997, K.G. Poole 1997). Ospreys also nest on artificial structures such as hydro poles and artificial nesting platforms (MacCarter and MacCarter 1979, Steenhof 1987), and where abundant, they have been documented to prefer suitable man-made structures over naturally occurring nesting habitat (Steeger et al. 1992). In Mugaha Marsh north of Mackenzie in the Williston watershed, a nest

tree used annually by breeding ospreys collapsed in the winter of 96/97. The nest tree was replaced by an artificial pole and platform by the local Mackenzie Fish and Game Club in the spring of 1997; a breeding pair of ospreys built a nest on the platform that spring, and successfully raised three young.Along the Williston Reservoir, osprey nests are located primarily in shoreline habitat where emergent snags from the flooding of the valley bottoms are concentrated. In 1997, 64% of the occupied osprey nests were within the inundation zone. Use of shoreline habitat has been documented throughout the range of the osprey, and the use of emergent trees or snags for nesting habitat as a result of flooding has been observed in numerous areas (Henny and Noltmeier 1975, Grover 1984, Hagan 1984 as cited in A. Poole 1989, Lloyd 1997).

Occupied ospreys nests within the Parsnip Reach were exclusively in trees within decay classes 4-6, with 90% of the nests found within the inundation zone. Nests in the Finlay Reach were found in every decay class with only 35% within the inundation zone. These differences may be explained by variations in the availability of various nest tree characteristics between the reaches of the reservoir. The morphometry of the three main flooded river valleys (reaches) were different prior to flooding as can be seen by examining the physical depth profile of the reservoir (see Barrett and Halsey 1985). The Finlay Reach has broad relatively shallow reservoir margins; the Parsnip Reach resembles the Finlay, however, the shallow margins are generally not as wide and drop off more steeply. The Peace Reach profile drops off precipitously with no discernible underwater shelf. The nature of the forests at the reservoir margins is likely affected by these differences, thereby resulting in varied nest site characteristics between the reaches. The numbers, size and soundness of emergent snags within the three reaches of the reservoir are affected as well.

5.1.7 *Nest Failure and Attrition*

Five active osprey nests failed during 1997 due to physical loss of the nest: three nests were flooded due to rising water levels over the breeding season, while the other two nest trees presumably collapsed. As trees in the inundation zone continue to age and decay, they will eventually collapse or be reduced in height to such an extent that they would be vulnerable to rising reservoir levels in spring. Over time, existing snags within the inundation zone will continue to disappear, and with no means of recruitment, available nesting sites for ospreys will decrease. Ospreys often reuse nests from year to year; in cases where nests are lost, ospreys typically rebuild nests, construct nests on alternate trees, or find new sites altogether.

Ospreys nesting around the reservoir perimeter in 1997 selected nest trees in advanced stages of decay. As these trees are unsound, they are more likely to collapse than sounder alternatives,

especially during storms. Between the 1995 and 1997 surveys conducted on the Williston Reservoir, 28% of the osprey nests found in 1995 were destroyed. Loss of nest sites between breeding seasons can delay clutch initiation because returning breeding pairs will need to find another suitable nest tree and construct a new nest there before laying. Delays such as this can negatively affect productivity (A. Poole 1989, Steeger and Ydenberg 1993).

5.2 Bald Eagles

5.2.1 Clutch Initiation

Limited data on expected egg laying dates for bald eagles were available for areas north of Prince George, B.C. prior to this study (Campbell et al. 1990). Clutch initiation dates were determined to be quite different for bald eagles and ospreys, and confirmed that separate surveys for each species were warranted during the 1997 survey season. The preliminary clutch initiation flights were also extremely useful in determining the timing of subsequent surveys. In general, the timing of bald eagle clutch initiation is correlated with the latitude of the nesting area (Stalmaster 1987). As latitude increases, breeding will commence at progressively later dates. In Florida, nest initiation occurs in early October, with egg laying starting in mid-November, while in Alaska, initiation occurs as late as the end of February, with egg laying commencing in early April (Stalmaster 1987). In northern Saskatchewan egg laying commences in mid April (Gerrard and Bortolotti 1998). In B.C., eagle clutch initiation can be as early as early February in southern areas (Campbell et al. 1990), while in the Williston watershed, we recorded the first signs of egg laying in early April which is consistent with other breeding areas at the same latitude (Stalmaster 1987, Gerrard and Bortolotti 1998).

5.2.2 Nest Site Density and Distribution

The density of occupied bald eagle nest sites in the Williston Reservoir (0.02 occupied nests/km of shoreline) is equivalent to the lowest recorded during other studies (Table 13). In general, breeding densities appear to be much higher for coastal eagle populations (up to 0.50 nests/km), while densities on interior lakes and rivers range between 0.02 and 0.10 (Table 13). Although at the low end of the scale, the Williston Reservoir density is comparable to those recorded for other interior lakes and rivers.

Densities of bald eagle nesting territories are governed by several factors. These include the availability of food (Gerrard et al. 1983, Hansen 1987, Dzus and Gerrard 1993); development of shoreline areas (Dzus and Gerrard 1989); stream gradient (Blood and Anweiler Unpubl data); human

Table 13. Bald eagle breeding densities from this (italicized text) and other studies in North America.

Location	Occupied nests per km shoreline	Authority
Rivers		**Interior B.C. and Yukon**
Kootenay R. (Goat Cr-Kootenay Lk)	0.10	Blood and Anweiler (unpublished)
Nechako R above Stuart R.	0.09	Blood and Anweiler (unpublished
Columbia R. (Athalmer-Donald)	0.09	Blood and Anweiler (unpublished)
Morice R. (Gosnell Cr-Owen Cr)	0.08	Blood and Anweiler (unpublished)
Swift R. (Swan Lk-Coconio Cr)	0.08	Blood and Anweiler (unpublished)
Koidern R. (White R.-Edith Cr)	0.07	Blood and Anweiler (unpublished)
Kluane R (below Kluane Lk)	0.06	Blood and Anweiler (unpublished)
Yukon R. (below Marsh Lk)	0.06	Blood and Anweiler (unpublished)
Peace R.	0.04	Blood and Anweiler (unpublished)
Major rivers in Williston Watershed	*0.02*	*This report*
Lakes and Resevoirs		**Interior B.C. and Yukon**
Squanga Lake	0.09	Blood and Anweiler (unpublished)
Pine Lake	0.08	Blood and Anweiler (unpublished)
Sulphur Lake	0.07	Blood and Anweiler (unpublished)
Cheslatta/Murray Lakes	0.03	Blood and Anweiler (unpublished)
Nanika/Kidprice/Stepp Lakes	0.02	Blood and Anweiler (unpublished)
Williston Reservoir	0.02	Booth et al. (1999)
Northcentral BC Lakes (and rivers)	0.04	K.G. Poole (1997)
Williston Reservoir	*0.02*	*This report*
Lakes in Williston Watershed	*0.03*	*This report*
Coastal		**West Coast Regions**
SE Alaska	0.50	Hodges and Robards (1982)
Chilkat Valley, AK	0.38	Hansen (1987)
Alaska	0.16	Corr (1974)
SE Alaska	0.15	Hansen and Hodges (1985)
Columbia River Estuary	0.14	McGarigal et. al. (1991)
Fraser Valley, B.C.	0.12	Farr (1988)
Gulf Islands, B.C.	0.12	Vermeer et al. (1987)
South coastal B.C.	0.09	Hodges et al. (1984)
Barkley Sound, B.C.	0.09	Vermeer and Morgan (1989)
North coastal B.C	0.08	Hodges et al. (1984)
Vancouver Island, B.C.	0.02	Lueke-joyce (1988)
		Southern U.S. Interior
Greater Yellowstone Ecosystem	0.04	Swenson et al. (1985)

activity (Fraser et al. 1985, McGarigal et al. 1991) and the availability of nesting sites (Corr 1974, Newton 1979 Hodges et al. 1984, Dzus and Gerrard 1989). Two factors, the availability of food and the amount of nesting habitat, whichever is in shortest supply, can exert a strong influence on nesting densities (Newton 1979). Where nesting sites are readily available, nesting pairs tend to be evenly spaced with distances between pairs correlated with differences in food supply (Newton 1979, Gerrard et al. 1983) as breeding eagles remain near nest sites to forage. If a reliable food source is not available, the area will not support a nesting pair (Hansen 1987). Conversely, where available nesting sites are limited, populations may exist at lower densities than the food supply could support (Newton 1979).

The quality of nesting habitat can be affected by the gradient, or flow rate of a river. Riverine areas with a low gradient are typically meandering in nature and generally have a well developed and highly complex flood plain. These floodplain areas provide ample nesting sites (large deciduous trees) and a diversity of prey species (e.g., ducks and fish). High gradient riverine areas lack this habitat complexity and tend to support fewer bald eagle nesting pairs (Blood and Anweiler unpubl data). It is difficult to determine which of the various factors may be contributing to the relatively low density of eagle nest sites around the reservoir and nearby rivers and lakes.

5.2.3 Clutch Size

Unlike ospreys, clutch sizes for bald eagles do not vary appreciably with latitude. Bald eagles will lay clutches of 1 to 3 eggs, however the majority of clutches (79%) contain 2 eggs (Stalmaster 1987). Average clutch sizes typically range from 1.90 to 1.97 eggs/nest (Stalmaster 1987). Our estimate of clutch size for bald eagles in the study area (mean = 1.90) fits within this range and is similar to clutch sizes measured in the Vanderhoof Forest District during the same breeding season (mean = 1.82, K.G. Poole 1998).

5.2.4 Productivity

Our bald eagle productivity estimates based on young/occupied nest along rivers, lakes, and reservoirs, were equivalent to the lowest of those reported for other North American bald eagle populations. However, the productivity of reservoir nests based on young/successful nest, is at the top end of the reported range (Table 14). Our assumed maximum nest failure rate of 56% in lake nests, also falls well within the range of nest failures noted in other studies. While our estimate of 0.92 young/occupied nest within the Williston Reservoir itself is below that for many other bald eagle populations, it is still higher than the minimum of 0.7 young/occupied nest site required to maintain a stable bald eagle population (Sprunt et al. 1973).

Table 14. Bald eagle productivity from this (italicized text) and other studies.

Location	Year(s) data collected	Coastal or Interior (C or I)	Aquatic system[1]	Young per occupied nest	Young per successful nest	# of nests	failure rate (%)	Authority
								British Columbia
SE Vancouver I.	1991-1994	C	O	0.97	1.58	125	37	Elliott (1995)
Johnstone Strait	1991-1994	C	O	0.34	1.14	97	69	Elliott (1995)
Clayquot Sound	1992-1994	C	O	0.31	1.21	101	73	Elliott (1995)
Barkley Sound	1992-1994	C	O	0.57	1.34	101	57	Elliott (1995)
Powell River	1992-1994	C	O	0.88	1.45	97	39	Elliott (1995)
Fraser Delta	1993-1994	C	O	1.30	1.63	20	14	Elliott (1995)
S. Moresby I.	1994	C	O	0.32	1.20	19	74	Elliott (1995)
Langara I.	1994	C	O	0.73	1.23	22	41	Elliott (1995)
Fraser valley, B.C.	1986-1988	C	R	1.47	1.74	39	?	Farr (1988)
Fraser Valley	1992-1994	C	R	1.30	1.51	62	11	Elliott (1995)
N. Central B.C.	*1997*	*I*	*L*	*0.71*	*1.00*	*7*	*56*	*This report*
S.W. Yukon	-	I	R	1.10	1.50	39	?	Blood and Anweiler (1990)
N. Central B.C.	*1997*	*I*	*R*	*0.55*	*1.20*	*22*	*43*	*This report*
CVWMA[2]	1982	I	R,L	1.40	1.50	11	9	Forbes and Kaiser (1984)
N. Central BC	1996	I	R,L	0.76	1.42	54	46	K.G. Poole (1997)
N. Central BC	1997	I	R,L	0.81	1.39	79	42	K.G. Poole (1998)
N. Central B.C.	1995	I	RL	0.86	1.35	36	60	Booth et al. (1995)
N. Central B.C.	*1997*	*I*	*RL*	*0.92*	*1.62*	*37*	*29*	*This report*
								Western United states
S. Central Oregon	1971-1984			0.95	1.50	169	-	Anderson (1985)
Washington State	1986-1994			1.03	-	7754	35	WSFW[3] (unpublished data)
Oregon State	1990-1996			0.95	1.56	1526	?	Issacs and Anthony (1996)
Washington State	1981-1985			0.87	1.42	173	*34*	McAllister et al. (1986)
S. Oregon	1978-1982			0.92	-	-	-	Issacs et al. (1983)
Washington State	1994			0.92	1.36	627		WSFW (unpublished data)
Washington State	1995			0.99[4]	-	-		WSFW (unpublished data)
S. Central Alaska	1989-1990	C	O	0.36-1.20[5]	-	1821	-	Bernatowicz et al. (1996)
S. Alaska	1978-1979	I	R	1.16	1.73	28	-	Ritchie (1982)
Alaska	1979-1980	I	R	1.20	-	55	-	Bangs et al. (1982)
Alaska	1989-1993	I	R	0.86	1.48	274	41	Steidl et al. 1997
Alaska	1989-1994	I	R	0.71	1.48	471	52	Steidl et al. 1997
								Other North American areas
USNF[7] -E. Region	1980-1988	-	-	1.11	1.60	4227	30-36	USDA Forest Service (1988)
Chesapeake Bay	1981-1990	C	O	1.18	1.71	1448	20-41	Buehler et al. (1991)
Colorado and SE Wyoming	1981-1989	I		1.21	1.91	85	-	Kralovec et al. (1992)
Saskatchewan	1968-1981	I	L	1.17	-		-	Gerrard et al. (1983)
Minnesota	1981	I	L	1.27	-		-	Grier et al. (1983)
N Florida	1973-1976	I	LR	1.14	1.59	189	-	McEwan and Hirth (1979)
Nova Scotia	1986	I	R	1.00	1.66-1.71	260	41	Austin-Smith and Dickie (1986)
G.Y.E.[6]	1972-1982	I	RE,R,L	1.02	-	80	-	Swenson et al. (1985)

[1] O=Ocean, R = river, L = lake, RL = reservoir

[2] CVWMA=Creston Valley Wildlife Management Area

[3] WSFW=Washington State Dept of Fish and Wildlife

[4] data only for areas that have had historically low productivity due to environmental contaminants

[5] productivity data from the area affected by the *Exxon Valdez* oil spill

[6] G.Y.E.=Greater Yellowstone Ecosystem

[7] USNF=U.S. National Forests

Factors that can affect productivity include: availability of food (Bangs et al. 1982, Hansen 1987); the influence of conspecific breeding pairs (Anthony et al. 1994); competition from nonbreeding eagles (Hansen 1987); environmental contaminants (Hickey and Anderson 1968, Wiemeyer et al. 1984, Anthony et al. 1994; Elliott 1995); human disturbance (Anthony et al. 1994); logging or clearing of land near nest sites (Anthony and Issacs 1989, Booth and Farr 1993); habitat loss due to residential development (Therres et al. 1993); and egg collection (Booth and Farr 1993, Wood and Collopy 1993). Studies examining the effect of human disturbance on bald eagle nesting success have yielded variable results. Mathisen (1968), McEwan and Hirth (1979), and Fraser (1985) found that human activities such as recreational activities, logging activity, pedestrian and vehicular traffic, had no negative effect on eagle nesting success, whereas Grubb (1980), Nash et al. (1980), Gerrard et al. (1985), and Anthony and Issacs (1989) concluded the opposite.

It is not known what, if any, factors are having an impact on the productivity of this eagle population, or whether this population is declining, stable or increasing. It is important to note that the nesting success of bald eagles is highly variable in undisturbed areas and has also been demonstrated to be geographically variable (Elliott 1995, Steidl et al. 1997).

5.2.5 *Nest Site Characteristics*

Bald eagles within the study area, particularly those around Williston Reservoir, selected primarily large, sound, deciduous trees within 100 m of water, although <10% of nests were found within water, or at the immediate shoreline. Similar observations have been made for bald eagles in other areas of central British Columbia (K.G. Poole 1997, Lloyd 1997, K.G. Poole 1998).

Tree species selection by nesting bald eagles is extremely variable across the species' range, however, our findings of eagles nesting predominantly in live deciduous trees is consistent with other studies in similar habitat types. Because of the variability of tree species used for nesting, it is generally believed that tree structure rather than species is the most important factor governing nest tree selection (Gerrard et al. 1975). Trees that bald eagles select for nest sites are generally taller and larger in diameter than surrounding stand conditions, often extending above the canopy (Andrew and Mosher 1982, Anthony et al. 1982, Green 1985, Stalmaster 1987, Anthony and Issacs 1989, Kralovec et al. 1992, Dzus and Gerrard 1993). Nest trees are often forked near the crown and frequently have live foliage extending above the nest (Mathisen 1983; Stalmaster 1987). These trees ensure adequate support for a nest, provide an open flight path to and from the nest and provide an unobstructed view of the surrounding area (Green 1985; Stalmaster 1987). Most of the trees found within the inundation zone of the Williston Reservoir typically do not provide these characteristics and therefore are rarely

used by nesting eagles. However, some trees near the reservoir margin appear to provide these characteristics and therefor provide the majority of nesting sites around the reservoir (90% of nest trees are outside of the inundation zone.

From published accounts it is evident that, in most cases, bald eagle nests are within 200-300 m of water (Dzus and Gerrard 1993; Corr 1974; Mathisen 1983; Vermeer et al. 1987; Oneil 1989; Booth and Farr 1993). Some nests have been found up to 1.5 km from water (McEwan and Hirth 1979). Selection of nest sites at greater distances from water are often associated with a lack of suitable nest sites along the shores of lakes (Stalmaster 1987). Although we did not actively search for nest sites in excess of 300 m from a waterbody shoreline, we assume that the number of nests beyond 300 m would continue to tail off with increasing distance (see Figure 10).

5.2.6 *Nest Failure and Attrition*

Eagles typically nest in tall, dominant, codominant or supercanopy trees. This often means that the nest trees are past their prime and are at various stages of decay (Mathisen 1983), and, as a result, have a limited additional life expectancy. Longevity also depends on tree species, weight of nest, and local weather patterns (Anderson 1985). In Minnesota and Michigan, Mattson and Grewe (1976) estimated that once a tree is established as a nest tree, it survives for an additional 9.5 years as a nest tree. In Saskatchewan, Gerrard et al. (1983) reported a 10% loss of nest trees per year. Over a two year period (between 1995 and 1997), 23% of the bald eagle nests found along the Williston Reservoir in 1995 were lost.

5.3 Diet and Fisheries

Bald eagle diets vary considerably depending on geographical location and can include birds, fish, mammals and various invertebrates. It is a widely held belief that coastal populations feed predominately on birds during breeding season and that interior breeders show a higher proportion of fish utilization (Knight et al. 1990). Although preferences for specific taxonomic prey groups (i.e. fish, birds) vary regionally, individual diets typically include many species within many taxa.

Osprey diets are not as varied as those of eagles and consist almost entirely of live fish (99% of diet, A. Poole 1989). It appears that ospreys are opportunistic in their prey selection. They will use any fish species that is abundant, accessible and of the right size. In coastal areas ospreys have been known to utilize a range of fish species and will readily switch from one species to another presumably when shifts in relative abundance occur (Greene et al. 1983). These shifts occur in coastal habitats as fish migrate over relatively large areas. Within small inland lakes and rivers,

ospreys tend to utilize the same prey species during an individual breeding season (Swenson 1978, Hakkinen 1978 as cited in A. Poole 1989) as fluctuations in numbers offish species are unlikely within one breeding season. However, in a reservoir in Idaho, Van Daele and Van Daele (1982) found that shifts in relative abundance of prey species taken by ospreys can occur, and also suggested that shifts in diet from one year to the next may also be affected by reservoir level.

In other areas of North America, inland ospreys have been reported to consume a variety of fish species (Swenson 1978, Van Daele and Van Daele 1982, Flook and Forbes 1983). Local diets are governed by species present in the system as well as the depth and size of lakes fished. Flook and Forbes (1983) found that fish consumed by ospreys were caught in similar relative quantities using surface nets, whereas Van Daele and Van Daele (1982) found substantial differences in use and availability offish species.

Few detailed fisheries surveys have been conducted within the Williston Reservoir since impoundment (Barrett and Halsey 1985, Blackman 1992). The construction of the dam and subsequent creation of the Williston Reservoir changed the system from riverine to lacustrine; subsequently the relative abundance of individual fish species has changed. Relative proportions of fish species captured during these surveys varied both with reservoir location and year of survey, however, Lake Whitefish, Longnose Sucker *(Catastomus commersoni),* and Peamouth Chub now appear to dominate within the reservoir (Figure 13). It is likely that these and the other fish summarized in Figure 13 play an important role in the diets of bald eagles and especially ospreys nesting within the Williston Reservoir area.

Many rivers flow into the Williston Reservoir providing habitat and rearing areas for various fish species. Bruce and Starr (1985) suggest that the amount of spawning habitat adjacent to the reservoir varies between the three reservoir reaches. The steep profile of the landscape surrounding the Peace Reach as well as its relatively low total drainage area does not support many accessible low gradient rivers and streams in which fish can spawn. Conversely, several relatively large low gradient rivers flow into the lower profiled Parsnip and Finlay Reaches, providing more suitable spawning habitat for many fish species. Both raptor species are known to forage within riverine systems throughout their distributions and likely utilize many of the tributaries to the Williston Reservoir. Access to fish within some of these rivers may be limited in some instances due to high turbidity during spring run-off.

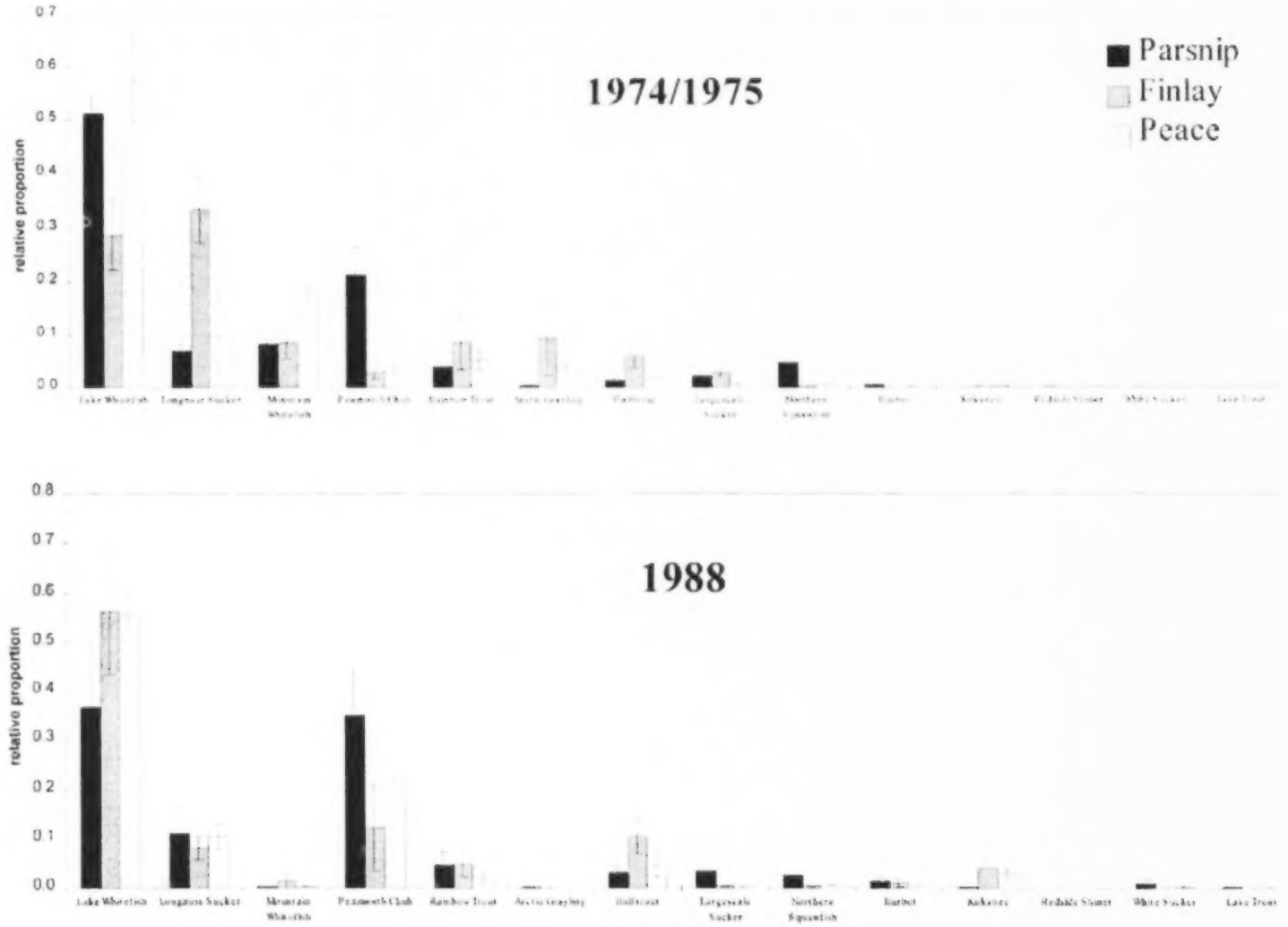


Figure 13. Relative proportions of fish species netted within each reach of the Williston Reservoir during two surveys. Data obtained from Barrett and Halsey (1985) and Blackman (1992).

Although we suspect that bald eagles and ospreys use both rivers and the shallow inundated bays of the reservoir for foraging, the relative importance of these areas remains unknown. Relating breeding success of bald eagles and ospreys to fisheries abundance is not possible due to the current lack of data on fish abundance. The limited fish data that are available were collected in 1974/75 and 1988 and likely do not reflect present conditions. Yearly variation in fisheries resources occur and can, to some extent, be linked to reservoir level fluctuations (A. Langston, PWFWCP, personal communication). Reservoir level, depth profiles, annual spring run-off levels, and relative densities of fishes likely all affect prey selection by both raptor species.

6.0 RECOMMENDATIONS

Currently, both bald eagle and osprey densities and productivity within the Williston Resevoir watershed appear normal in comparison with other breeding populations. The Williston Reservoir raptor populations should continue to be surveyed in the future to monitor changes in densities and/or productivity. We recommend that intensive surveys like these conducted in 1997 should be conducted again in 5 years (2002). If declines in densities or productivity from current levels in either species is detected, further investigations may be warranted at that time:

1. Decline in densities of ospreys or eagles:

If breeding densities of eagles or osprey decline, an assessment of the available nesting sites should be conducted. Osprey densities may decline if their primary nesting sites (snags within the inundation zone) continue to decay and fall. In this case, replacement or provision of additional nesting sites for ospreys through erection of artificial poles and platforms and/or topping of live trees should be considered. Eagle nest sites could be enhanced by topping trees immediately adjacent to large sound trees of suitable structure for nesting, to provide a flyway to such trees. If nest site availability is not determined to be limiting, then more intensive research into other potential limiting factors (eg., food resources and availability) is recommended.

2. Decline in productivity of ospreys or eagles:

If productivity of eagles or ospreys declines substantially from current levels, an intensive study should be initiated to determine the factor(s) affecting and limiting productivity in the population(s).

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